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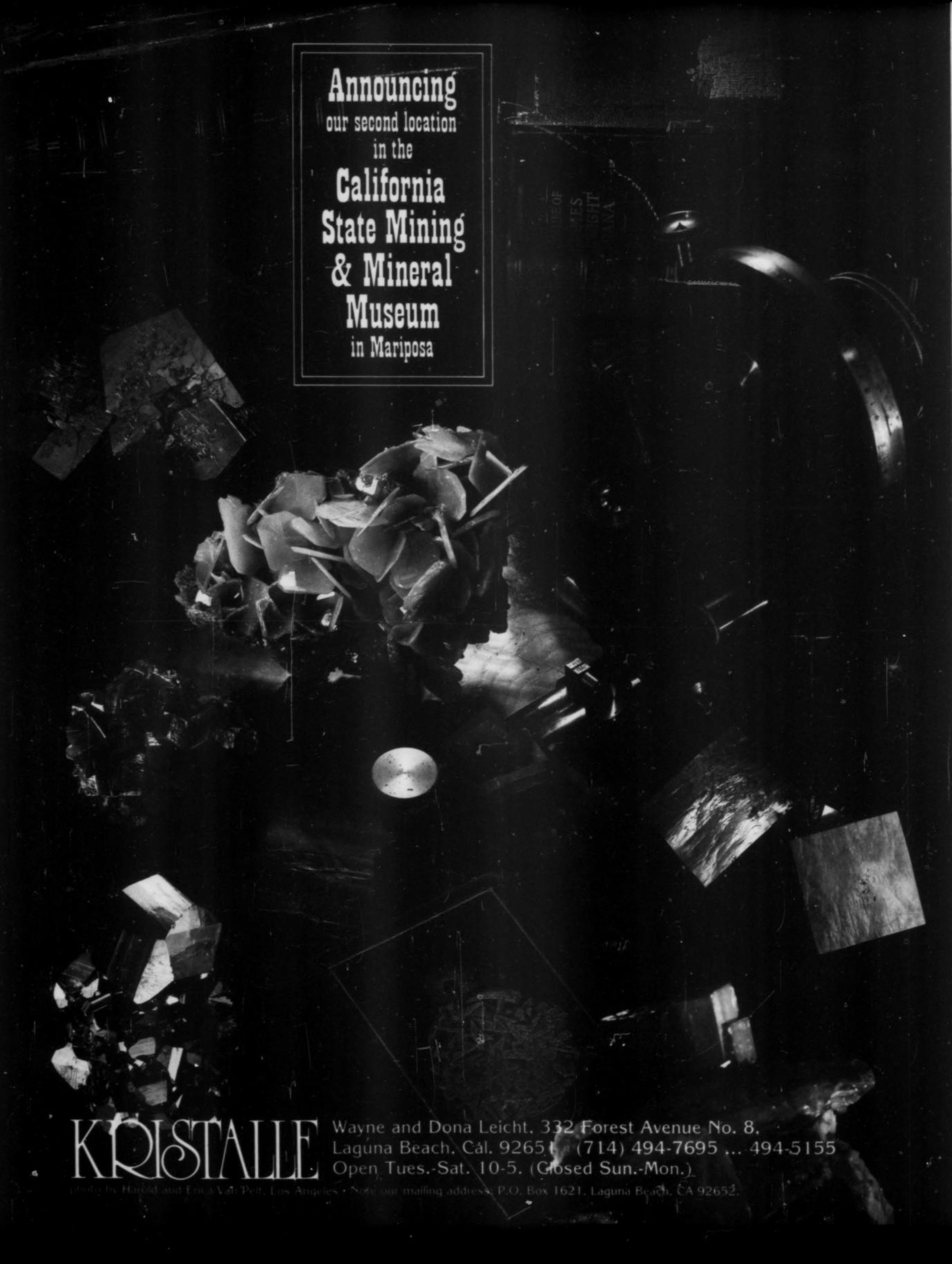

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Guest Editorial:

On the Role of Museums and the Amateur Mineralogist

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INTRODUCTION

The relationship between the amateur and professional mineralogist is vitally important for the future development of the Science. This synergistic relationship is often best developed at the interface provided by museums, both local and national.

Communication between the professional mineralogical fraternity and the amateur is achieved at many different levels, and through different media—both verbal and non-verbal. Display policy, publications, accessibility of reference material and education via lectures and demonstrations all contribute to the well-being of this special relationship.

Much emphasis is placed on numbers of visitors through the door when reviewing the success of a museum, but in the case of the serious amateur mineralogist different criteria should be applied. This sector of the general public represents only a small percentage of museum users, yet is by far the most valuable to the curatorial or research worker in terms of potential, mutually beneficial cooperation.

The following discussion is based on the situation in the United Kingdom; the problems and proposals identified may or may not be applicable in other areas.

WHO ARE THESE "AMATEURS"?

"Amateur" is typically defined as: "One who loves, is fond of, or has a taste for, anything," and "One who cultivates anything as a pastime." It is important to note that "amateur" does not necessarily mean "un-professional" or "having faults."

The amateur mineralogist ranges from the most casual observer, through the "pebble-collector" and systematic collector to professionally qualified individuals, trained either in earth sciences or other scientific disciplines, who can bring other skills to the field of mineralogical studies. This spectrum of abilities and interests must be addressed when considering how best to utilize the resources of the amateur population. Formal qualifications (not necessarily in mineralogy—perhaps in chemistry or physics) must be set against the value of the amateur's field and other practical experience.

In the United Kingdom, there are probably somewhere between several hundred and a few thousand individuals who may be considered to be amateur mineralogists. Of these, relatively few have any formal scientific training or indeed appreciation of how the Scientific Community is organized and behaves. This lack of knowledge forms a barrier to communication.

From among this body of people, a much smaller number have forged links with academic institutions, museums and research workers, and may thus have access to reference material, literature and analytical services. Relatively few amateurs make extensive use of national library services.

A network of clubs and societies exists, although relationships between such groups are generally weak and activities tend to be concentrated in fairly narrow areas of interest.

WEAKNESSES AND STRENGTHS

It is possible to identify a number of relative weaknesses and strengths within the amateur community, and these are summarized below:

Weaknesses

(1) The amateur/collector tends to be fairly secretive about discoveries and sites.

(2) Individuals are deterred from publishing data, both by the "secretiveness" mentioned above, and also the rigors of thorough editing of manuscripts.

(3) There is still a prevalence of the "pretty blues and greens" brigade—those who collect and are interested only in aesthetically attractive material.

(4) Much of the material submitted to National Museums for identification is probably of relatively little interest to the museum itself, and the time taken to deal with such inquiries, together with financial considerations, represents a significant strain on museum resources.

(5) In some cases, claimed identifications are clearly suspect, but, more importantly, others may be plausible but nonetheless inaccurate. Once a record is wrongly publicized it is very difficult to "disinfect the system."

(6) Many amateurs do not realize when they have found something rare or scientifically significant.

(7) Much of what is collected is poorly curated and rendered inaccessible (by lack of knowledge among professionals of its existence).

Strengths

(1) Amateurs spend a vast amount of time observing minerals in the field and are strongly motivated to find something new or different, rare or interesting, bigger or better than before.

*This guest editorial was originally presented as a paper at the "Mineralogy and Museums" conference in London, England (July 1988).

(2) This determination is followed by equal vigor "back at base," where typically even more time is invested in studying the material collected.

(3) Amateurs almost invariably know their own patch better than anyone else, and have the opportunity to establish good relationships with landowners and local people.

(4) The amateur is likely to be "in the right place at the right time."

(5) The more experienced amateur mineralogist will recognize that he doesn't know what something is, and hence that it may be important. This distinction is possibly the most pertinent to our current discussion, and emphasizes the need for accurate recording of locality data; identification is always possible in isolation, but the locality information, if lost, can rarely be recovered.

(6) Much scientifically valuable material undoubtedly resides in amateur collections and is unknown to research workers.

(7) The amateur would like, almost without exception, better contact with museums, universities, research workers and so on.

CRITICISMS OF THE MUSEUM SYSTEM

Museum displays are often static for many years due to financial and space restrictions. This can result in the institution gaining a reputation merely as a warehouse, rather than a dynamic, working resource to be tapped. An element of change regularly introduced into exhibits offers the opportunity to attract new visitors, and to encourage previous visitors to return.

The proportion of curated material actually on display, or accessible to the public, is generally small. A judgment must be made by the curator as to what safely can be handled to ensure that maximum benefit is derived, both by the museum and the visitor. There seems little point in having the greater part of collections securely stored but never looked at.

Funding is often directed at glamour projects, and although this may make sound commercial sense in terms of "bodies through the gate," it is important to retain adequate funds for proper collection management and basic services.

WHAT DOES THE MUSEUM VISITOR WANT?

Like any industrial or commercial enterprise, it is possible to analyze what the visitor wants from a museum. If we look first of all at display policy several recommendations emerge:

Displays

(1) Incorporate a mix of static and changing displays.

(2) Provide a "recent acquisitions" display, and make sure that this is changed regularly. The amateur mineralogist/collector particularly appreciates knowing what is new or being produced currently at given localities.

(3) Regional mineralogy displays provide a useful source of reference for the enthusiast, and local museums in particular are often well placed to provide this type of facility.

(4) Attention to lighting and quality of presentation is vitally important, and points to note here include undesirable reflections and opportunities for visitors to photograph material (where permitted).

Accessibility

Turning next to access, the requirements of the amateur mineralogist/collector are rather different from those of the general public, and bearing in mind the relative numbers of these two groups, it should not be difficult to provide a tailored service for the former.

(1) "Behind the scenes" access is universally appreciated by the amateur. It must be recognized that there is a potential security problem, but the advantages of offering access are worth the effort. This could be controlled by societies to some extent, and admission could be based on personal knowledge or recommendation, and might confer certain privileges. Trust is the key.

(2) "Open Days" where visitors can be escorted around laboratories or workshops, with special displays or demonstrations, have proven very popular in the United Kingdom. Both the British Museum (Natural History) and the Geological Survey (Keyworth) have run very successful events in the last few years, with thousands of visitors in attendance.

Interaction

One of the potentially most beneficial areas for development is interactive contact. This may take many forms:

(1) Practical workshops and teach-ins.

(2) Publications to encourage and attract newcomers, e.g. beginners' field guides based on mineralogical sites.

(3) Lectures and talks based on the collections, staff research interests, etc.

(4) Catalog information readily accessible for individual research.

(5) Availability of an identification service. This is a complex issue, with consequent drain on resources, but perhaps a screening service could operate to ensure that only "worthwhile" material is submitted.

PROBLEMS

Communication between the amateur and professional requires encouragement and improvement, including better access to National Collections, although it is appreciated that this may be difficult to arrange.

Many amateurs cannot visit museums between Monday and Friday, and technical staff are rarely if ever available at weekends. This effectively blocks the opportunity for interchange of ideas and information in many instances. If this problem could be resolved, the resulting benefits could be considerable for both sides.

A responsible attitude with regard to site data and collecting practice is an essential prerequisite for greater openness and interchange of data.

KEY PROPOSALS

(1) It is suggested that consideration should be given to enlisting the help of knowledgeable amateurs, particularly at the local museum level.

(2) An organized basis for amateur/museum contact should be established so that joint action may be taken in the case of dump removal (e.g. Wheal Gorland, Cornwall) or building over of localities, and in-filling of quarries. Similarly, notification of temporary exposures would maximize the material salvaged.

(3) Offer a limited amount of display case area to clubs or individuals for changing displays, e.g. recent finds, theme displays, or locality displays. The talent is available—why not use it?

(4) Formulate a policy on bequests of collections or individual specimens and publicize it. How does one go about making a bequest? What material is of interest? Possibly a "voucher scheme" could operate along the lines of Kidney Donor Cards, identifying specific specimens and the institution to which they should be sent.

CONCLUSION

All of the above should encourage the development of closer and more active relations between the amateur and the professional, and one tangible spin-off should be an increase in the amount of material donated to national collections for safe keeping.

The amateur community can help the museum professional, and wants to be involved—please welcome them!

notes from the EDITOR

KOREAN MINERAL STAMPS

In our letters column in the March-April issue we pictured three mineral stamps published by the government of North Korea. Depicted are the minerals lengenbachite (from a photo by Eric Offermann), rhodochrosite (from a photo by Olaf Medenbach) and annabergite. To make the record complete, the Dutch photographer Pieter Stemvers is responsible for the annabergite photo. It was originally published as the cover photo on *two* European mineralogical journals: *GEA* in the Netherlands and *Geonieuws* in Belgium. The specimen itself is owned by Dr. Henri Dillen.

CALCITE COLLECTORS

The *International Calcite Collectors Association* is currently being formed, for the purpose of trading specimens and perhaps circulating a newsletter. Interested parties should contact Dr. Morton Metersky, 725 Cheryl Drive, Warminster, PA 18974. Mort will be establishing a mailing list which will be distributed to all members.

CHECKLIST FOR AUTHORS

All authors should take note of the following guidelines. Adherence to these guidelines will reduce the amount of time required to process your article, and will greatly endear you to the editor.

1. Paper. All manuscripts must be submitted on $8^1/_2$ x 11-inch (22 x 28-cm) paper. Foreign authors please cut your paper down to size . . . our files are not designed for larger sheets.

2. Typing. All manuscripts must be typed and double-spaced throughout, including references and figure captions. The first line of each new paragraph must be indented.

3. Word processors. Manuscripts printed on non-letter-quality printers will not be accepted.

4. Extra copies. Submit all manuscripts in triplicate. Photos and figures may be submitted as one set of originals and two sets of photocopies.

5. References. References must be typed precisely according to our usual format (see published articles for examples). Spell out all journal titles in full.

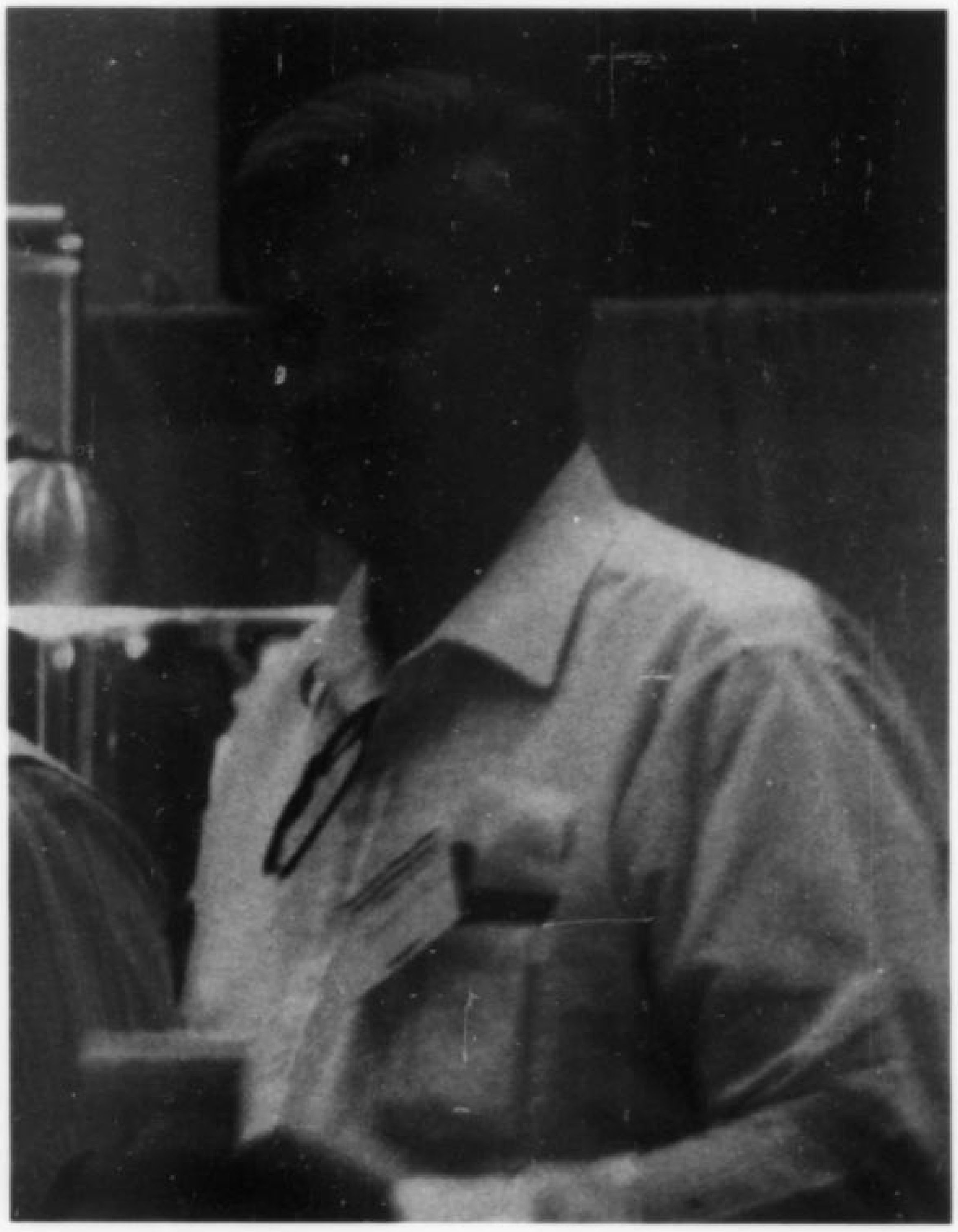
6. Photographs. Prints must be submitted loose in numbered envelopes. Do not write on the front or back of photos; doing so can ruin them for publication,

7. Measurements. All measurements must be given in metric units, except for: (a) historical purposes and quotations, (b) car mileage distances to U.S. localities, (c) addition of parenthetical English equivalents for special emphasis or clarity, and (d) proper names, e.g., mine levels.

8. Credits. Caption data for specimen photos must include (a) species name, (b) specimen or crystal size, (c) color (if photo is B&W), (d) name of photographer, and (e) name of specimen owner.

9. Mineral names. Use of new mineral names not approved by the International Mineralogical Association is forbidden. Use of varietal names (except for a few entrenched gemological terms such as emerald) is discouraged except in a historical context, and proper definition should always be given.

10. More detailed suggestions may be found in our *Author's guide to writing locality articles* (vol. 17, no. 6, p. 393–400) and *Photographer's guide to taking mineral specimen photographs* (vol. 18, no. 3, p. 229–235).



NOTICE

Died, John Whitmire, 62, owner of *Whitmire's Minerals* in Yuma, Arizona. John was a longtime wholesale mineral dealer who supplied fine Mexican minerals to dealers, museums and collectors for over 30 years. He was born February 22, 1927, in Ramona, California. In his youth he collected Indian artifacts; as his love for prospecting grew, he turned his attention to mineral collecting. One of his first collecting adventures as a young man was with his uncle, Robert Dye, one of the early California mineral dealers; they traveled together to the Four Peaks area in Arizona's Mazatzal Mountains and collected gem-grade amethyst. After serving two years in the army during the Korean War, he expanded his field of collecting to include Mexico, and formally began his mineral business in 1956. In the early 1970's he procured large amounts of silver from the New Nevada mine in Batopilas, Chihuahua, Mexico and legrandite from the Ojuela mine in Mapimi, Durango, Mexico. These were major finds and have not since been equalled. In quest of new material, he traveled extensively throughout Mexico, braving remote areas and contending with the many difficulties of foreign business. He had claims on several significant mining properties, including, but not limited to, the San Francisco mine in Sonora, the Veracruz amethyst locality, and the sulfur mine in Baja. He was a long-time wholesale dealer in the Tucson Gem and Mineral Show.

Gene & Jackie Schlepp

GREAT POCKETS:

THE "BRIDAL CHAMBER"

LAKE VALLEY, NEW MEXICO

Robert W. Eveleth
New Mexico Bureau of Mines & Mineral Resources
Socorro, New Mexico 87801

The famous vug known as the Bridal Chamber, discovered at Lake Valley, New Mexico, during the early 1880's, is so well known that it has entered oral tradition and become part of New Mexico's folklore.

INTRODUCTION

So much has been written about the famed Bridal Chamber of Lake Valley, New Mexico, it is difficult to separate fact from fanciful journalism. Each account contains at least one true fact: the Chamber was a very real discovery indeed, and without doubt one of the richest concentrations of chlorargyrite (AgCl) or cerargyrite ever discovered in North America. In fact, it was so unbelievably rich that it attracted many of the leading scientists and famous capitalists of the day. Even the most stalwart professionals of the engineering and geological world were so influenced by its dazzling beauty and obvious wealth that much of their effort and capital were expended toward finding another. What follows is an account of the events leading up to its discovery and the ultimate effect it exerted upon the Sierra mining companies of Lake Valley.

A GRASS-ROOTS DISCOVERY

Time and again the question is asked why the discovery of New Mexico's bonanza mineral deposits lagged so far behind surrounding states and territories. The reasons are many and include such factors as the absence of navigable bodies of water and distance from population centers and coastal areas.

These are minor, however, compared to the threat to one's health posed by the predacious Apache Indians, who ruled over much of New Mexico as late as the mid 1800's. Thus, it is most unlikely that George W. Lufkin, sometime cowboy, sometime prospector, was either alone or discovered the Lake Valley silver deposits totally by accident, as has been suggested more than once in the popular press (e.g. Jones, 1904). More likely he passed through the area in his round of duty with a group of cowboys, probably in the employ of the McEverts Ranch, noticed the dark iron- and maganese-stained outcroppings, and quietly vowed to return at the first opportunity.

*Reprinted from *New Mexico Geological Society Guidebook*, 37th Field Conference, Truth or Consequences (1986).

Return he did during August 1878, with at least one companion, probably Chris Watson (some accounts include McEverts himself). They proceeded to sink several prospect holes and quickly discovered bonanza silver ores literally at grass roots (Fountain, 1882; *Republican*, 1883b; Jones, 1904). But as so often happened during early years of mineral discovery in the west, the discoverers were not wealthy men. When their funds were quickly depleted, they returned to Hillsboro to build another grubstake. Indian problems delayed their return to the diggings for a time, but meanwhile they were able to get John A. Miller, the post trader at Fort Bayard, interested in backing them financially. As a result, Lufkin and Watson would realize only a modest sum for their efforts, while Miller would become wealthy (Fountain, 1882).

Inevitably, news of the discovery leaked out and caused a rush into the new district, which from the beginning appears to have been called Lake Valley (Fig. 1) after the small lake nearby. The first camp that sprang up was named Sierra City. The principal claimants at that time (and probably indicative of some of the first residents of Sierra City) were Lufkin and Watson, as well as M. V. Cox, R. M. Sherman and Brothers, A. Barnaby II, H. Wells, and John A. Miller (*Mining World*, 1882a; 1882b). Sierra City grew rapidly, but was struck by tragedy almost immediately when the notorious Victorio and his band of marauding Apaches attacked the camp and sent 16 men to permanent rest on the hill above the lake (*Republican*, 1883a). "The brutality of the Indian raids through Arizona and New Mexico in these days would scarcely be believed now but they stain in deep scarlet the early records of these territories and are still well remembered by the early residents" (MacDonald, 1909).

EASTERN CAPITAL COMES TO SIERRA CITY

With a temporary return to peace, the district developed sufficiently to attract needed outside capital. J. A. Miller turned his attention toward the financial centers of Pittsburgh and New York. Two groups

Figure 1. **Lake Valley, New Mexico, shown above ca. 1890, had already seen its first boom-and-bust cycle with the failure of the Sierra Grande Company and the organization of the Silver Mining Company of Lake Valley. The diminutive wooden boxcars of the A.T. & S.F.R.R. occupy one of the sidetracks above the depot; the mill was located ⅓ mile farther up the track to the west (right). Photo Henry Schmidt, NM Bureau of Mines & Mineral Resources Collection, courtesy Richard H. Jahns.**

headed by George D. Roberts of New York and J. Whitaker White of Philadelphia were definitely interested, but were unsure because of the great risks involved: the Indians, distance to market, and guarantee that Lake Valley ores were as rich as claimed by Miller. They obtained the services of a well-known mining engineer George Daly to properly assess the situation (Fountain, 1882; MacDonald, 1909).

Daly, doubtless raised and educated in the east, had gone west to find fame and fortune in the Leadville, Colorado, area mining camps (*Mining World,* 1881). He was in fact the general manager of the Robinson Mine at Kokomo, some 15 miles north of Leadville (and now buried under Climax's tailings). Daly's report was favorable to say the least, and as a result the Lake Valley properties were purchased for $300,000 (*Mining World,* 1881). This included a $100,000 payment to John A. Miller, a hefty commission to Daly, and the remainder went to Lufkin, Watson, McEverts, and unspecified others.

At the time of transaction in early 1881, the only "permanent" building in Sierra City was George Lufkin's one-room cabin (Fountain, 1882; Jones, 1904; MacDonald, 1909). Daly would become the first general manager of the new venture and would bring Bernard MacDonald down from Leadville as his superintendent.

THE SIERRA COMPANIES

The eastern financiers took a most curious course of action to develop and mine the deposits: a syndicate was formed which then organized four companies—the Sierra Grande, Sierra Plata, Sierra Bella, and Sierra Apache—each owning a specific group of mineral properties which were to be mined independently. The milling facilities, however, were operated by the Sierra Grande Company and appear to have been either jointly owned or perhaps used on a toll basis. This four-company system quickly led to a rather complex state of affairs, and it was found advantageous to consolidate the various holdings through mergers or outright purchase.

The four Sierra companies were actually preceded by the Lake Valley Mining Company, and perhaps also by the Sierra Bonanza Company. Early in 1881, Lester A. Bartlett of Washington, DC, visited Lake Valley "and subsequently aided in organizing" the Lake Valley Mining Company. This would be the first corporation with capital in the district and would later be reorganized into the Sierra Bella Company, but other than this little is known about these companies (*Mining World,* 1882a; 1882b; 1882d).

The Sierra Plata Company was the first to be consolidated into the Sierra Grande; this occurred almost immediately (toward the end of 1881, doubtless hastened by the discovery of the Bridal Chamber) and was followed by the Sierra Apache during 1882, and finally by the Sierra Bella in early 1886 (Burchard, 1883; 1884; *Engineering and Mining Journal,* 1886a). Thus, the stage was set for the totally unexpected discovery of the Bridal Chamber in mid-August 1881.

THE BRIDAL CHAMBER

Although high-grade silver ore seemed to be everywhere, Daly decided to initiate development on the sizeable outcropping on the Sierra Grande and Sierra Bella properties. The orebody in the Lincoln claim (Sierra Grande ground) was well exposed in an open cut excavated earlier, and an exploration drift was collared at this point and driven in a westerly direction to define the limits of pay ground (Fig. 2). According to MacDonald (1909), this drift had attained a length of some 800 ft, all in ore, with the silver grade increasing steadily to the west, in the direction of Stanton claim (Sierra Plata ground). To faster determine the extent of the orebody and to improve ventilation, it was decided to move ahead to the property line common to the Lincoln and Stanton claims and sink a shaft. Since this was to be a joint venture of the two companies, the opening was called the "joint shaft." (The Lincoln and Stanton claims were subsequently renamed Carolina and North Carolina, respectively, when surveyed and patented [Sawyer, ca. 1881, *Engineering and Mining Journal,* 1888a].)

The breakthrough was totally unexpected, and it is fortunate indeed that so many first-hand accounts describing the fabulous vug survived. MacDonald was doubtless present at the time, although the names of the actual miners have been lost to history. Jones (1904) tells us that John Leavitt had a lease on the property and was the one to discover the Bridal Chamber. Perhaps Jones meant to say that Leavitt held a shaft-sinking contract with, or was employed by, the Sierra Grande/Plata Companies. After clearing away 4 ft of soil, the shaft penetrated 20 ft. of limestone before entering the ore zone. At this point the ore assayed 40 ounces/ton and silver content increased rapidly; finally, at 30 ft a solid mass of horn silver 4 ft thick was encountered that

averaged an incredible 15,900 oz/t silver (MacDonald, 1909).

MacDonald tells us he "named the ore deposit cut in the 'joint shaft' the 'Bridal Chamber' because of the sparkling light reflected by the myriads of crystals of cerargyrite and calcite studding the roof of the open space over the chloride streak. The purest specimens assayed 20,000 oz/t silver and the average across the 4 ft face was 15,000 oz" (MacDonald, 1909). The subsequent breakthrough from the tunnel side was called the "Cat Hole" by the miners (Hague, 1882b). It is one of the great ironies in New Mexico's mining lore that at almost the very hour the joint shaft broke the 4 ft streak of horn silver, George Daly along with his companions Doc Williams, Tom Hughes, and Green were killed by Chief Nané and his braves. In honor of this "gentleman kindly remembered by all the old timers," Sierra City was renamed Daly. Daly itself would be short-lived and abandoned when the area surrounding the 20 stamp mill became the newest townsite called simply Lake Valley (*Republican,* 1883b; MacDonald, 1909; Jones, 1904; *Mining World,* 1882a).

News of the fabulous strike spread rapidly and, of course, most people brushed the story aside as just another wild promotional scheme by those crazy New Mexicans. Even the *Socorro Miner,* a publication devoted to the promotion of the territory's mineral wealth, said: "Worse and worse. Those fables about the Lake Valley mines continue to grow at every report. The correspondent now declares that a great cave of almost pure silver has been discovered and that the output will be $100,000 per day" (!) (*Mining World,* 1882a). And they had every right to be skeptical, for seldom has the earth yielded so rich a treasure in so small a space (see e.g. Sawyer *in Mining World,* 1882b; Clifford, ca. 1882).

The Sierra Grande Company was soon inundated with inquisitive experts and professionals from all walks of life. The list of famous

***Figure 2.* Open cut and stope, Carolina claim, Lake Valley, New Mexico, ca. 1890. This view has often been identified as the Bridal Chamber itself, when in fact it is more likely the location of Daly's exploration drift which eventually broke into the Bridal Chamber several hundred feet away. The ore zone has subsequently been stoped out around the original drift, leaving the opening seen here. Photo Henry Schmidt, NM Bureau of Mines & Mineral Resources Collection, courtesy Richard H. Jahns.**

visiting dignitaries reads like a Who's Who of the late nineteenth century: the eminent mineralogist from Yale, Benjamin Silliman; the famous paleontologist Edward D. Cope; F. M. Endlich, formerly of the Smithsonian Institution; Governor Tabor of Colorado; and Governor Safford of Arizona. Even seasoned and hardened professionals, having "seen-it-all" at bonanza camps like Leadville, were not prepared for the sight confronting them in the Bridal Chamber. Robinson (1882) examined the deposit for James D. Hague (of Comstock fame) in January 1882 and reported "I have before seen nothing like it by which I could judge of its merits. Leadville never showed anything richer or more easily got at . . . ," and then almost prophetically closed by saying: "I don't believe it will stay but there is Millions in it for speculation." Gillette (1882a, b) visited the property a few days later and reported to Henry Janin that the chamber contained a "beautifully large and solid looking streak," "containing ore which is horribly rich (from 10 to 15,000 oz)." Gillette fortuitously provided Janin with an on-the-spot sketch of the chamber (to my knowledge, the only such sketch to survive), which is herein reproduced (Fig. 3).

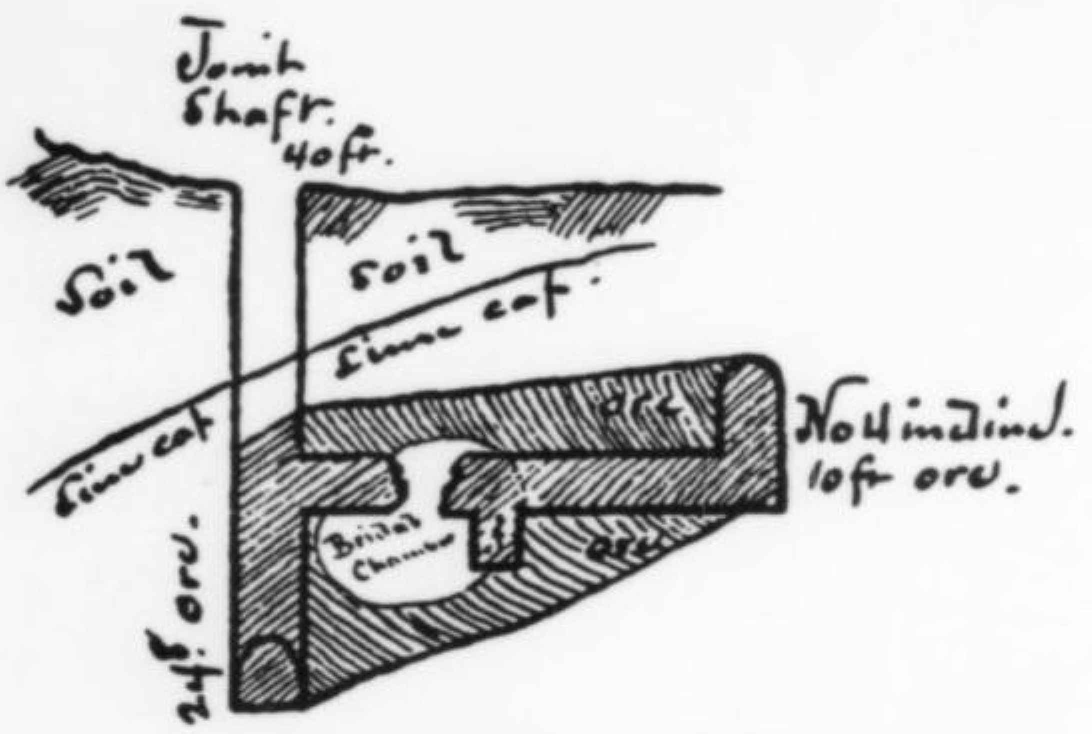


Figure 3. **Daniel B. Gillette's on-the-spot cross-sectional view of the Joint Shaft, Bridal Chamber, and "Cat Hole" (right side of chamber). James D. Hague papers, courtesy Huntington Library, San Marino, California.**

JACKSON'S BABY

D. H. Jackson assumed the managerial duties so tragically vacated by Daly and was kept rather busy escorting the visitors (if they had the proper credentials) into the Bridal Chamber. By early 1882 the chamber was opened up into four galleries and in one of these was a large mass of chlorargyrite called "Jackson's Baby," measuring 6 ft x 4 ft x 2 ft and said to be valued at between $60,000 and $80,000. It was here that Governor Safford was said to have offered $50,000 for all the ore he could personally remove in 10 hours (*Republican,* 1883; Fountain, 1882).

A 640-pound piece of this ore was sent for display to the National Mining Exposition at Denver. To further bolster the claim of Lake Valley's richness, Jackson sent a telegram to Dr. George S. Haskell at the Exposition stated: "we took out a piece of horn silver today; weight over 10,000 pounds; worth over $60,000" (probably "Jackson's Baby" alluded to above). "I took out today altogether, with only eight men in eight hours, over one hundred and thirty thousand dollars" (*Mining World,* 1882c).

Amidst all the excitement no one, it appears, had the presence of mind to preserve the sight on a photographic plate, but fortunately Fountain (1882) left us the following vivid description:

> Instinctively one raises his candle to get a better view of the magic chambers. Here the rock is black and looks like iron slag from some huge forge; there [it] has a reddish cast, as though the internal fires to which it owes its origin have not yet cooled off; yonder the ore loses its characteristic as a rock formation and resembles a huge mass of soft quicksilver amalgam, both to the touch and to the eye; in another spot it hangs in beautiful, glistening, soft chloride crystals which feel damp in the hand, and when compressed yield to the pressure and assumed the shape of the closed palm, like dough. The latter formation is more readily smelted than any ore we ever saw before, the flame of the candle sending the virgin silver dripping down the wall like shot. We had heard and doubted this story, and were perfectly well aware of the fact that it requires 1,873

Figure 4. **Henry Schmidt, assayer, surveyor, and self-appointed photographic chronicler of the Black Range area during the late nineteenth and early twentieth centuries, posed a group of miners and mill hands at the "Bridal Chamber Mine" (i.e., in an open cut on the Carolina claim) around 1890. Photo courtesy Museum of New Mexico, #56218.**

degrees Fahrenheit to fuse silver, yet we are now living witness to the fact that the flame of the candle held against the projecting crystals of chloride of silver in these mines, unaided by the blowpipe, is sufficient to fuse them in half a minute.

REORGANIZATION AND A CRASH HEARD 'ROUND THE WORLD

The effect upon the seeing-is-believing public was amazing enough, but for the Lake Valley companies it was, in the long run, devastating; the incredible vision of sudden wealth mesmerized the otherwise hard-nosed engineers, geologists, and capitalists alike. A decision was hastily made to erect a 20 stamp, pan-amalgamation mill that cost approximately $100,000 and was notorious even in that day and age for producing 60–250 oz tailings (*Engineering and Mining Journal,* 1883; 1884; MacDonald, 1909). Similarly, $20,000 was expended on a 30 ton smelter which was said to be "of a pattern that would have done credit to a museum of antiquities" (*Engineering and Mining Journal,* 1883; 1885). Worse, one failure followed another. The first mill was quickly replaced with a Russell Lixiviation plant which was only moderately successful. Designed and built by the Colorado Iron Works, a reputable firm, it seems that it worked fine as long as the feed was relatively high grade and easily crushed, but it should have been designed to handle larger amounts of tougher, lower-grade ores. Once again, the company based its future on bonanza ores. Last but not least, the stockholders naturally demanded their share of the windfall. This resulted in paying out hundreds of thousands of dollars in dividends when in fact at least a portion of these funds should have gone into the company's treasury to carry it through more difficult times which, as with any mining operation, were inevitable (*Engineering and Mining Journal,* 1883; 1884; 1893; *Mining World,* 1885).

By late 1886 it was all over for the Sierra Grande Mining Company. President John B. Mellor summed it up in his report to the stockholders saying they "were in debt, the mill was running at a loss; that several thousand dollars wages were due and must be paid; that $10,000 in judgements had been entered up against the property; and that immediate action was necessary" (*Engineering and Mining Journal,* 1886b). The action taken by the few stockholders who would remit 10 cents per share was to organize the new "Silver Mining Company of Lake Valley" from the remnants of "the once famous Sierra Grande Company" (*Engineering and Mining Journal,* 1888b).

The new company was only moderately successful and even as late as January 1893 was still directing part of its efforts "in the hope of finding another bonanza like the Bridal Chamber" (*Engineering and Mining Journal,* 1893). But the silver crash was the coup de grace and the company ceased operations permanently in August 1893. Despite the 2.5 million ounce bonanza from the Bridal Chamber, an additional million ounces from Thirty Stope, and a total production of 5–7 million ounces in a little over eleven years (Clark, 1894; MacDonald, 1909), the overall Lake Valley silver operations appear to have lost money.

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During the late 1800's, the Stayton mining district yielded some of the finest stibnite crystal groups ever found in the United States. Specimens were acquired by the best private collectors of the day, including George Vaux, Lazard Cahn, Carl Bosch, Washington Roebling, George English, Frederick Canfield and C. S. Bement. The mines have been idle for many years and are now completely sealed to prevent entry.

INTRODUCTION

The Stayton mining district was an important source, from the mid-1870's to around 1900, for some of the finest stibnite crystal groups ever recovered in the United States. The occurrence has been discussed by a number of authors including Hanks (1884), Irelan (1890), Aubury (1903), Eakle (1908) and Laizure (1925). Although cinnabar was the principle ore mineral of the district, several mines, notably the Ambrose, Blue Wing and Shriver, contained veins of well crystallized stibnite.

Many of these "old time" stibnite crystal groups (showing a habit twisted about the *c* axis) can be found in a number of museums, universities and private collections across the United States (Table 1) and are usually identified as being from the Ambrose mine, Hollister, California.

Located on the crest of the Diablo Range, the Stayton mining district is about 146 km southeast of San Francisco and 21 km northeast of Hollister, California near the northwestern corner of the *Quien Sabe* 15-minute quadrangle. Most of the district mines are in western Merced County, although some may be found to the north in Santa Clara and west in San Benito Counties. The Miocene (?) volcanic field presents a rugged topography which can be seen for a distance of 50 km. During early California history, local Indians hunted and gathered food in the area and their artifacts are occasionally found in the valley streams and among the rugged volcanic rocks.

The authors first visited the district during the summer of 1963 in hopes of finding some remaining samples of the stibnite crystals described in early mining literature. Age and dangerous conditions such as flooding, caving and carbon dioxide gas pockets had rendered most of the mines in the district unexplorable by that time. Because of these conditions, we only explored the Stayton mine, although it was partially caved and flooded in the lower workings. At that time, only a small pile of partially oxidized massive antimony ore was found remaining by one portal. Inside the adit, which still contained mine rails, several specimens of fine crystallized stibnite, in divergent groups 1 to 2 cm long, were removed with difficulty from the hard quartz breccia wall rock. Also, abundant masses of post-mine iron and aluminum sulfates were collected from the damp mine walls rich in pyrite.

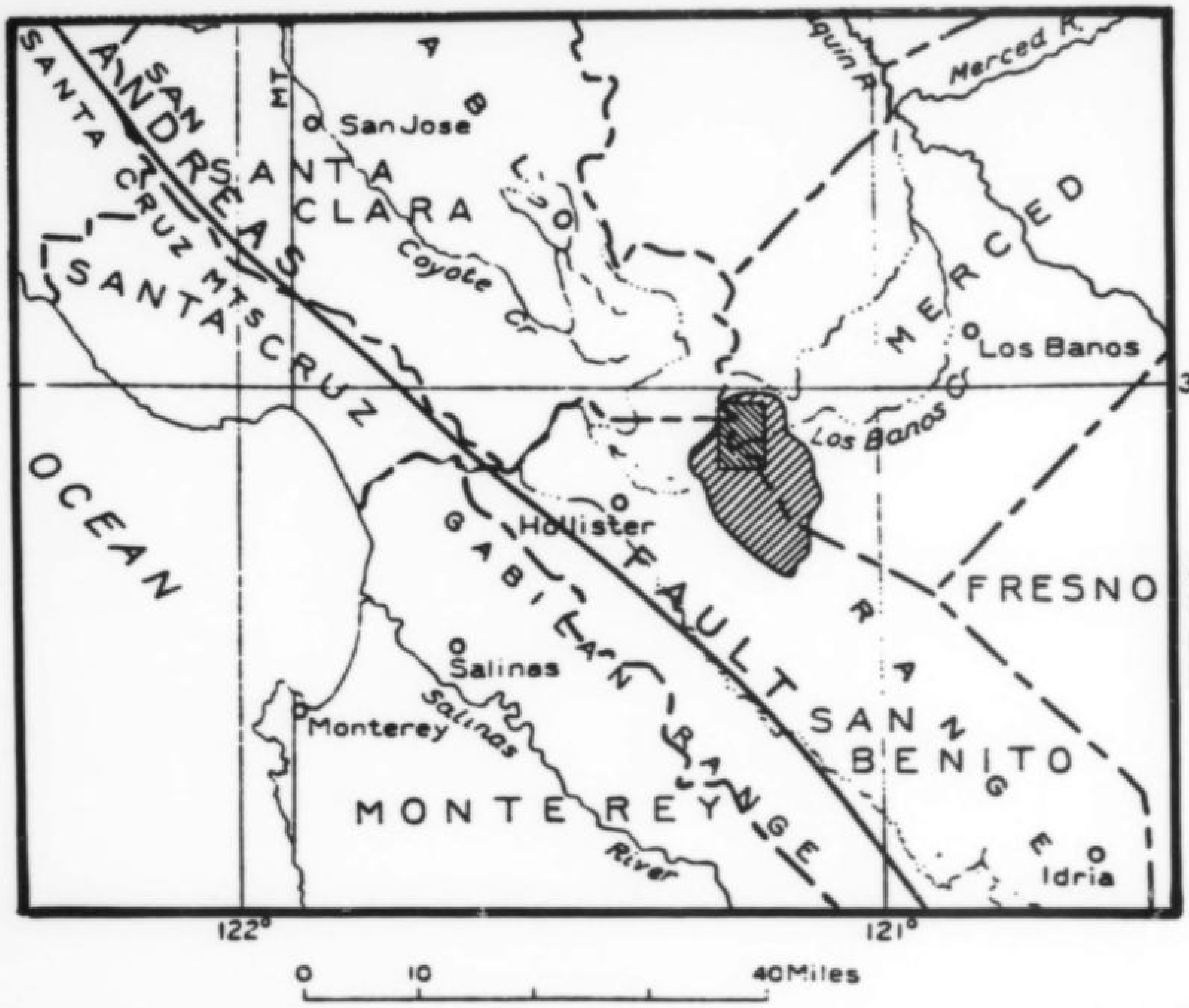

***Figure 1.* Map of central California showing the Stayton district within the approximate extent of the Miocene (?) volcanic field (after Bailey and Myers, 1941).**

During another visit to the area in 1987 to obtain site photographs and additional specimens for this study, we found the portals completely sealed and the old antimony ore stockpiles removed. A reconnaissance of the general area revealed several ore samples partially buried in the small creek passing by the sealed Stayton portal. Some exceptional needle-like stibnite crystals were discovered in these samples, as were pockets containing well-preserved stibiconite pseudomorphs after stibnite.

The district mines are now all sealed to prevent personal injury, and because they are on private land, special permission must be obtained before visiting them. No underground collecting is possible; as we found on the last trip, very little of mineralogical interest remains on the old dumps.

HISTORY

The Stayton mining district, formerly known as the McLaud district, was established about 1870 and worked first for its antimony ore until 1875, when cinnabar was discovered, making mining more profitable. By 1876, the Stayton Mining Company had gained control of the Gypsy, Stayton, and several smaller mines in the district.

According to Forstner (1903), mercury production prior to 1880 was reported to have been about 1000 flasks (a flask of mercury contains 34.7 kg of liquid mercury). The Comstock mine in the northern part of the district was also discovered in the 1870's and produced about 300 flasks prior to 1880. From 1880 to 1920, little is known of the district's production, but it is believed to have been small (Bailey and Myers, 1941). Records are available only for the Stayton mine between the years 1920 and 1947, and report about 390 flasks produced from intermittent operations. The Stayton mine was reactivated in 1955 and a small amount of mercury was recovered (Holmes, 1965).

The first recorded production of antimony ore was in 1893, when 58 tons of ore were produced. Nothing is known of the production prior to 1893, although mining first began in 1875. Minor production was again recorded in 1895, 1916–17, 1926–27, 1941 and 1943 (Wiebelt, 1956). It is estimated that no more than a few hundred tons of ore were mined from the district (Bailey and Myers, 1941).

In the mid 1940's, the Cordero Mining Company obtained a lease from R. B. Knox to explore the antimony potential of several veins just southwest of the Stayton mine. They named this operation the Quien Sabe antimony mine. (*Quien sabe* is Spanish for "who knows?") Development work consisted of more than 530 meters of drifts and crosscuts along the veins. No production was attempted by the operators and the mine was idle in 1956 (Wiebelt, 1956).

R. B. Knox of Hollister, California owned most of the mines in the district, including the Stayton, Yellowjacket, Blue Wing and Gypsy. The property is now under the control of the Knox estate. None of the mines in the district was operating in 1963 during our visit and, from the general appearance of the area, no mining activity had occurred since the mid-1950's.

Considering that a number of fine old stibnite crystal groups were preserved and included in the collections of several private collectors, museums and universities in the United States, some collecting during mining operations must have occurred in the district, although no record exists of such collecting activities. The best samples probably were recovered before 1900, when antimony mining was at its peak, and it is quite possible that a number of mining engineers and geologists associated with the California Mining Bureau and local universities made trips to the area.

GEOLOGY

Aside from a reconnaissance map made by Forstner in 1903, little geologic work had been done in the district prior to 1941, when Bailey and Myers mapped the mines and described the geologic features, including potential ore reserves. In 1972, Bahia-Guimaraes studied the genesis of the antimony-mercury deposits including the general geology of the area. A summary of this work follows.

The district is underlain chiefly by Tertiary igneous rocks which extend over an area of about 260 square kilometers. Exposures of pre-Tertiary rocks are relatively small, and lie mainly in the lowest canyon bottoms and around some volcanic plugs that have upturned the invaded rocks. Parts of the district are covered by Quaternary landslides and alluvial deposits. Folded and faulted rocks of the Franciscan assemblage (pre-Tertiary) form the basement throughout most

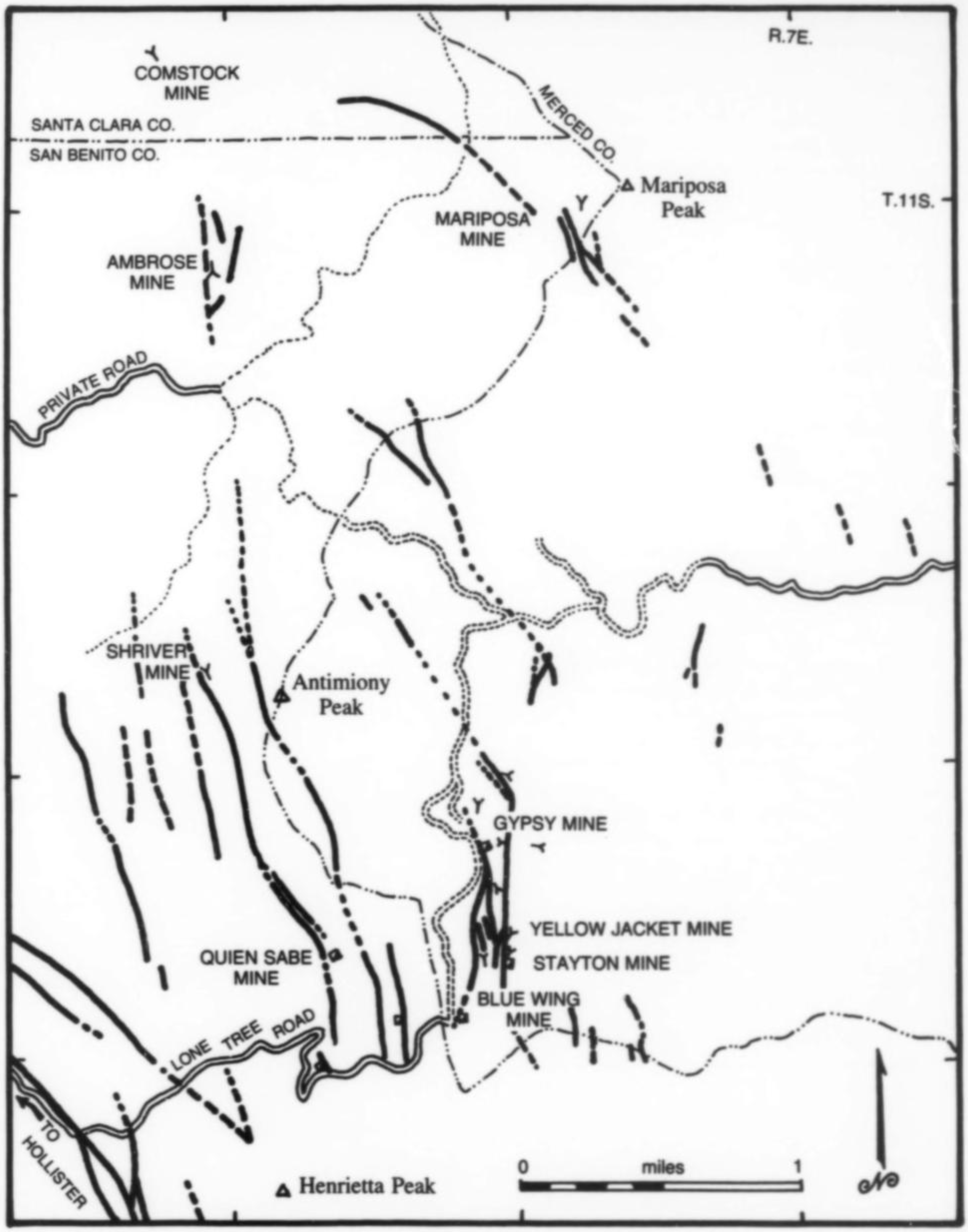

Figure 2. **Map of the Stayton mining district showing the location of the individual mines and faults (heavy lines) (after Bailey and Myers, 1941).**

of the area but no dominant structural trend was recognized in them. Feldspathic sandstone, dark gray shales, and conglomerate of the Upper Cretaceous unit of the Great Valley sequence occur in the northwestern and western portion of the area.

Another group of pre-Tertiary rocks includes serpentine and masses of silica-carbonate rock derived from serpentine. This serpentine is intrusive into the Franciscan rocks but nowhere cuts the Cretaceous rocks. Pebbles of serpentine have been observed in the Cretaceous conglomerate. Unconformably overlying these rocks is a 16-meter limestone layer of the Miocene Vaqueros Formation. The Franciscan assemblage and the Great Valley sequence are separated by the Coast Range thrust fault.

The oldest Tertiary rocks include basaltic extrusive rocks, flows and interbedded layers of agglomerate and tuff which are separated from the older pre-Tertiary rocks by a major unconformity. These basaltic rocks are arched in a north-trending asymmetrical anticline which was formed and partially eroded before the emplacement of the andesitic extrusive rocks that make up the second unit. The third unit consists of andesitic intrusive bodies, some older than the andesitic extrusive rocks, some younger, and some of undetermined relative age. The youngest Tertiary igneous rocks are intrusive bodies of rhyolitic rock. Although some of the intrusive bodies turned up the adjacent layers of older rocks, other cut sharply across the bedding.

The north-trending faults are the structural features of interest in the district, along which some of the orebodies occur. All of the known orebodies in the district are along faults in the basaltic rocks, except for one in an andesitic intrusive body and one in a body of silica-carbonate rock.

DISTRICT MINES

Most of the district mines have been described in detail by Bailey and Myers (1941), Wiebelt (1956) and Holmes (1965). During the field work conducted by Bailey and Myers in 1941 only one antimony mine was open for mapping, the Ambrose. Other descriptions were based on the knowledge of the late R. B. Knox of Hollister, California.

Alta mine

The Alta mine was mentioned by Hanks (1884) and Eakle (1908) as the source of long, divergent prisms of stibnite, as were several other mines on the slopes of Antimony Peak. Bailey and Myers (1941), however, did not include the Alta in their description of the district. It is entirely possible that the Alta was one of the many smaller prospects located on the southern slope of Antimony Peak, first worked in the 1870's but later incorporated into one of the larger mines, possibly the Shriver.

Ambrose mine

The Ambrose mine, also known as the Rip Van Winkle mine, is located in section 30, T11S, R7E near the northeastern corner of San Benito County. Bailey and Myers (1941) state that at the time of their field work the mine had not been in operation for more than 20 years. No production data exists, but the total amount of stibnite ore probably did not exceed 100 tons. In 1941, the lowest level was found flooded and the portal caved; however, the upper portal was still accessible.

Stibnite was the only ore mineral noted and, together with a little milky quartz, formed a nearly continuous vein that strikes N 20° W and dips 65° SW, close to the southern border of an andesitic intrusive body. The vein, which is split at several places, swells from less than 1 cm to a width of 25 cm within a short distance. The average width of this vein in the main stope is about 10 cm. The wall rock is kaolinized for approximately a meter adjacent to the vein and contains minor amounts of disseminated pyrite.

In the upper level, the vein pinches in the roof and was not found on the hillside immediately above. At the top of the ridge along the continuation of the altered zone, a 10-cm vein of nearly pure stibnite is exposed in a small trench.

Some of the finest crystallized stibnite from the district has come from this mine, notably the stoped area, which contained the richest stibnite.

Blue Wing mine

Owned by the Knox estate and located several hundred meters southwest of the Stayton mine in section 5, T12S, R7E, the Blue Wing mine is believed to have produced a few tons of hand-sorted antimony ore (Bailey and Myers, 1941). The mine was found to be flooded in 1941 and the description of the underground workings was supplied by the late R. B. Knox.

The workings consist of a vertical shaft approximately 25 meters deep with a drift to the north and a short, shallow drift to the south. The ore is in northward-trending quartz-stibnite veins in basalt which are apparently discontinuous, but locally they contain lenses of nearly pure stibnite slightly less than 30 cm thick.

Cinnabar was found in vugs and along fractures in the upper 7 meters of the stibnite veins; however, it did not occur below this level. During 1941 a few tons of 50% stibnite ore remained on the dump. Both Aubury (1903) and Eakle (1908) included the Blue Wing mine in their list of mines containing good stibnite crystals.

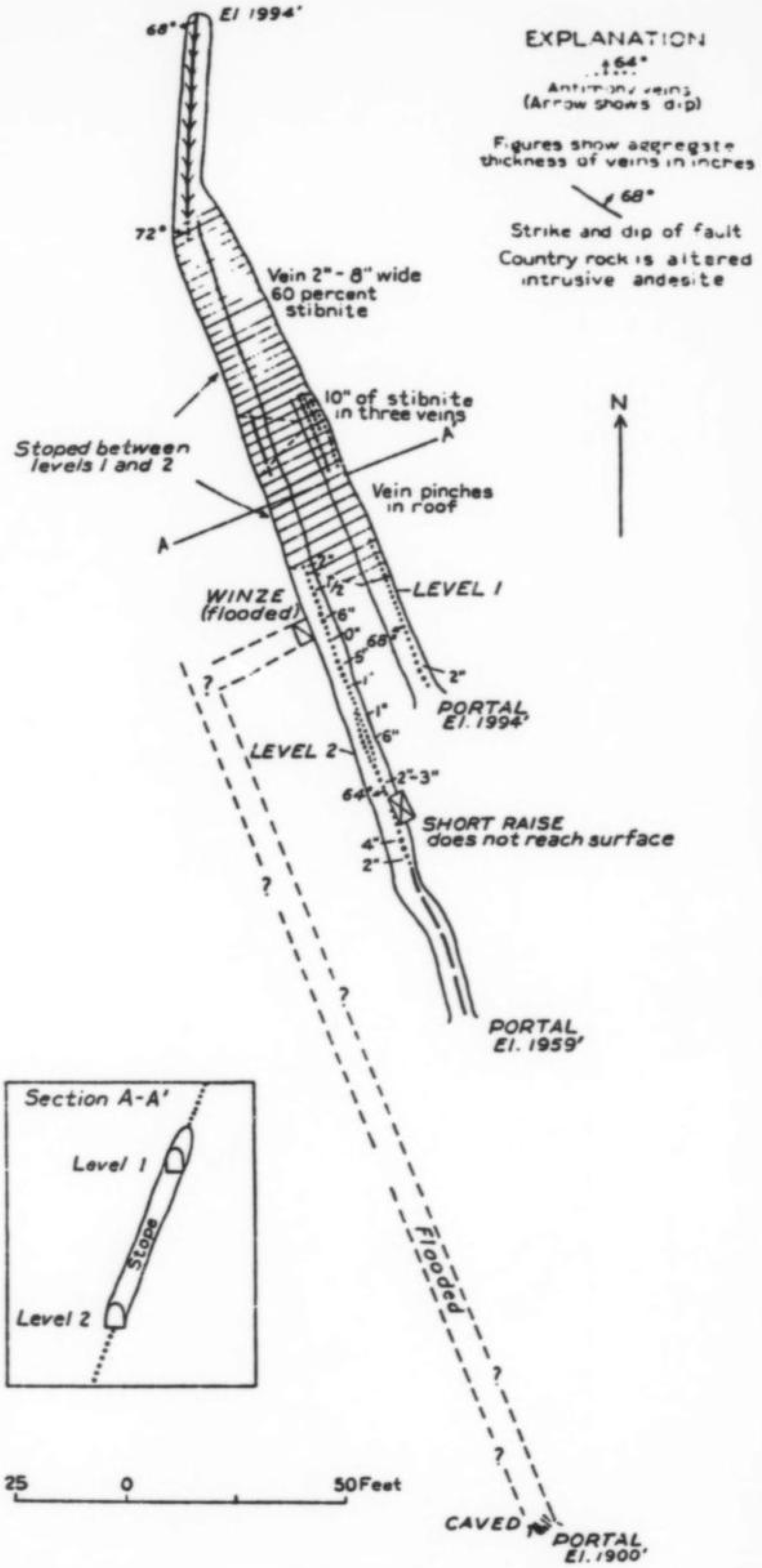

Figure 3. **Underground workings of the Ambrose mine showing the location of stibnite mineralization up to 25 cm wide (after Bailey and Myers, 1941).**

Comstock mine

Located in section 19, T11S, R7E, Santa Clara County, the Comstock mine was discovered about 1870 and worked until 1880 with a production of about 500 flasks of mercury. Since that time only sporadic prospecting has been done with no production. Forstner (1903) reports that the mine had not operated for a number of years. A body of cinnabar ore occurred in silica-carbonate rock along the hanging wall of a moderately dipping northeast-striking fault. An incline shaft, partially accessible, extends to a depth of about 80 meters. Short east-west drifts with some stoping were driven on several levels from the shaft.

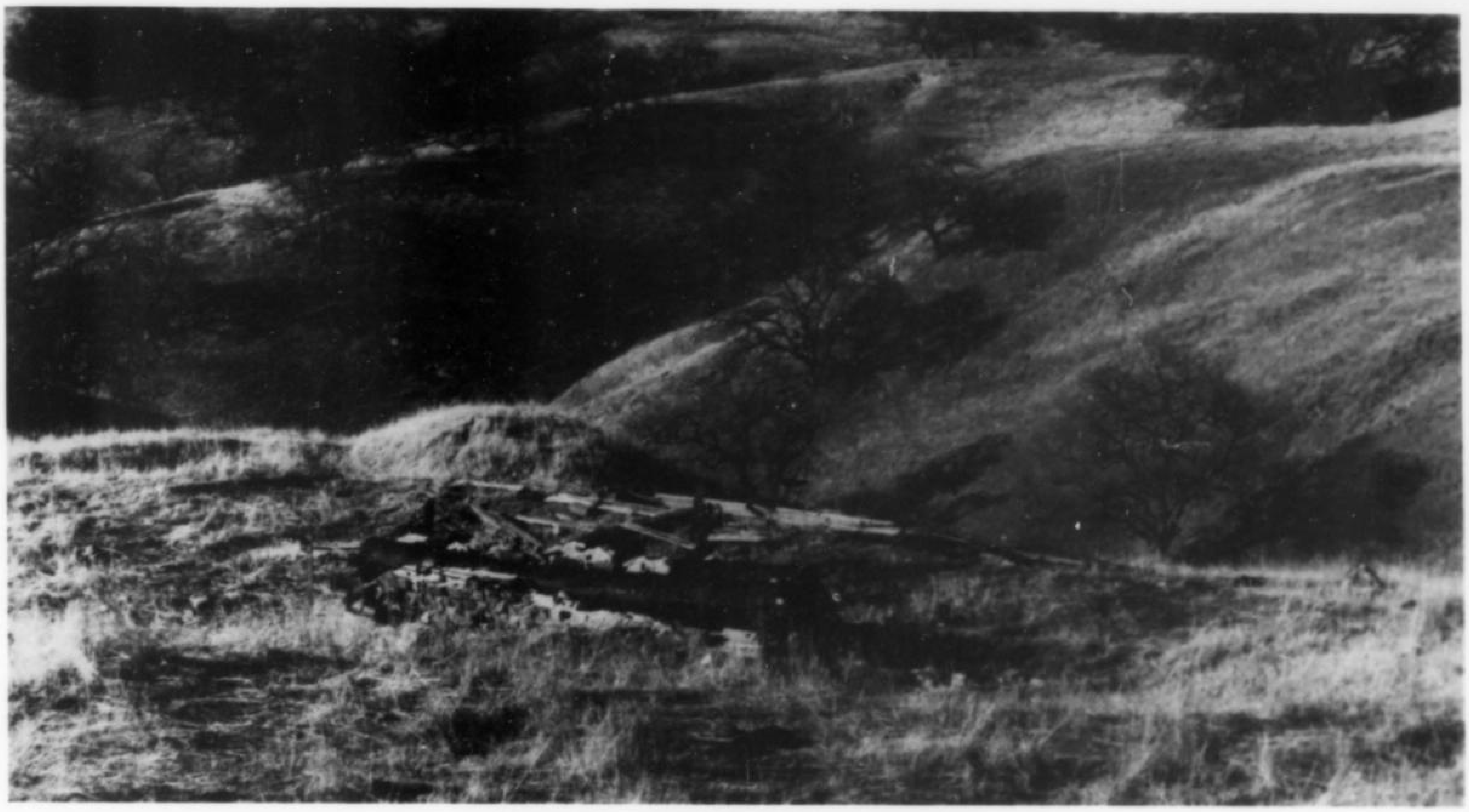

Figure 4. **Remains of an old two-pipe mercury retort at the Gypsy mine. The retort was fired by wood. G. Dunning photo, 1987.**

Gleason mine

The Gleason mine was one of several mines mentioned by both Hanks (1884) and Eakle (1908) as containing good samples of crystallized stibnite. Together with the Alta mine, the Gleason was probably one of the smaller prospects first worked in the 1870's on the southern slope of Antimony Peak.

Gypsy mine

The Gypsy mine is in section 5, T12S, R7E, western Merced County; it was discovered during the 1870's. The mine operated until 1880, with an output of about 500 flasks of mercury, which was included in the output of the Stayton mine (Holmes, 1965; Bailey and Myers, 1941).

The site contains a silicified breccia zone along a northwest-trending, southwest-dipping fault in altered basalt where cinnabar occurred as vein fillings and fracture coatings. Mine workings included a stope open to the surface extending to an inclined depth of about 30 meters, several drifts and two adits. An old inaccessible inclined shaft is reported to extend to a depth of 13 meters below the workings.

Mariposa mine

The Mariposa mine is in section 28, T1S, R7E, San Benito County, and was located during the 1870's. Only a small production of mercury prior to 1903 was reported (Forstner, 1903).

Disseminated cinnabar was contained in a wide shear zone in basalt, striking northwesterly and dipping moderately to the northeast. A 100-meter adit, several short drifts and a raise are included in the mine's development.

Quien Sabe mine

The Quien Sabe mine is located in sections 5 and 8, T12S, R7E, and follows a number of stibnite-bearing veins just southwest of the Stayton mine. The surrounding rocks consist of basaltic flows and tuffs. Numerous mineralized faults, with variable dips from nearly vertical to 35° westerly, contain both stibnite and cinnabar.

Stibnite is the principle mineral and antimony oxides are quite common in the outcrops and in the tunnel level. The workings consist of about 530 meters of drifts and crosscuts along the strike of the veins. A number of old, shallow shafts and pits are located on the outcrops and date to the 1870's.

The Cordero Mining Company acquired a lease on the property from R. B. Knox, the owner. In 1950, the Bureau of Mines conducted a diamond-drilling program on the property to establish the tenor and extent of the stibnite-bearing veins. Some silver was noted in the assays. As of 1956, all of the work had been confined to development and exploration with no reported production. The mine was idle in 1956 (Wiebelt, 1956). Around 1960 the mineral dealer Forrest Cureton (personal communication) mined thousands of fine stibnite specimens here, including lustrous groups of crystals to 5 cm and duller crystals to 15 cm.

Shriver mine

The Shriver mine, also known as the Red Metal mine, is located in section 31, T11S, R7E, and was first worked in the 1880's for stibnite. Some cinnabar was mined from shallow surface deposits but the production was small.

The mine consists of two adits with a combined length of about 400 meters which follow a stibnite and cinnabar-bearing vein in basalt. The cinnabar was concentrated along small fractures and pods in the upper part of the vein.

Irelan (1890) reports assay values of $25 gold and $17 silver per ton (1890 dollar value). A shipment of 1.5 tons of high-grade antimony ore was made in 1893 (Crawford, 1894). The Shriver is one of the several antimony mines mentioned by Irelan (1890), Hanks (1884) and Eakle (1908) as producing good samples of crystallized stibnite. Forrest Cureton (personal communication) mined a 40-cm wide vein of massive stibnite for specimens here in 1960.

Stayton mine

The Stayton mine is located in section 5, T12S, R7E, western Merced County, and was first worked in 1870. It has been the principle mercury producer in the district, although its first activity was confined

Figure 5. **View of one portal of the Stayton mine which had not been closed; extensive caving was noted within 10 meters of the portal. G. Dunning photo, 1987.**

Figure 6. **Underground map of the Stayton mine showing the location of extensive stoping for stibnite and cinnabar (after Bailey and Myers, 1941).**

to the mining of antimony ore. Mercury production began in 1870 and continued until 1880 with a reported output of 1000 flasks. Intermittent operation during 1912–18 and 1920–47 yielded an additional several hundred flasks.

The mine was reactivated in 1955 and a small amount of ore was mined from accessible veins. We found the mine idle in 1963 during our visit and mostly caved and flooded. The property was drilled in 1979 by the Homestake Mining Company for gold but no production resulted.

Old workings, which included the main level driven about 100 meters to the south along the ore zone, and an 80-meter inclined shaft with levels at 23, 46 and 78 meters were largely inaccessible. The 46-meter level reportedly had 258 meters of drifts. Extensive raising and stoping was done along the main ore zone and parallel hanging wall fissures.

Stibnite occurs throughout the mine but only in small amounts. Pockets containing bright crystals to 3 cm were common in the quartz breccia wall rock in 1963.

Yellow Jacket mine

Located about 160 meters northwest of the Stayton mine, the Yellow Jacket explores a fresh to kaolinized basalt. The main workings consist of a 60-meter adit extending to the south and a 90-meter crosscut, most of which lies west of the adit. The veins are locally broken but are nowhere highly brecciated. In only a few places do they contain any cinnabar or stibnite. No significant amount of ore was produced during the mine's activity.

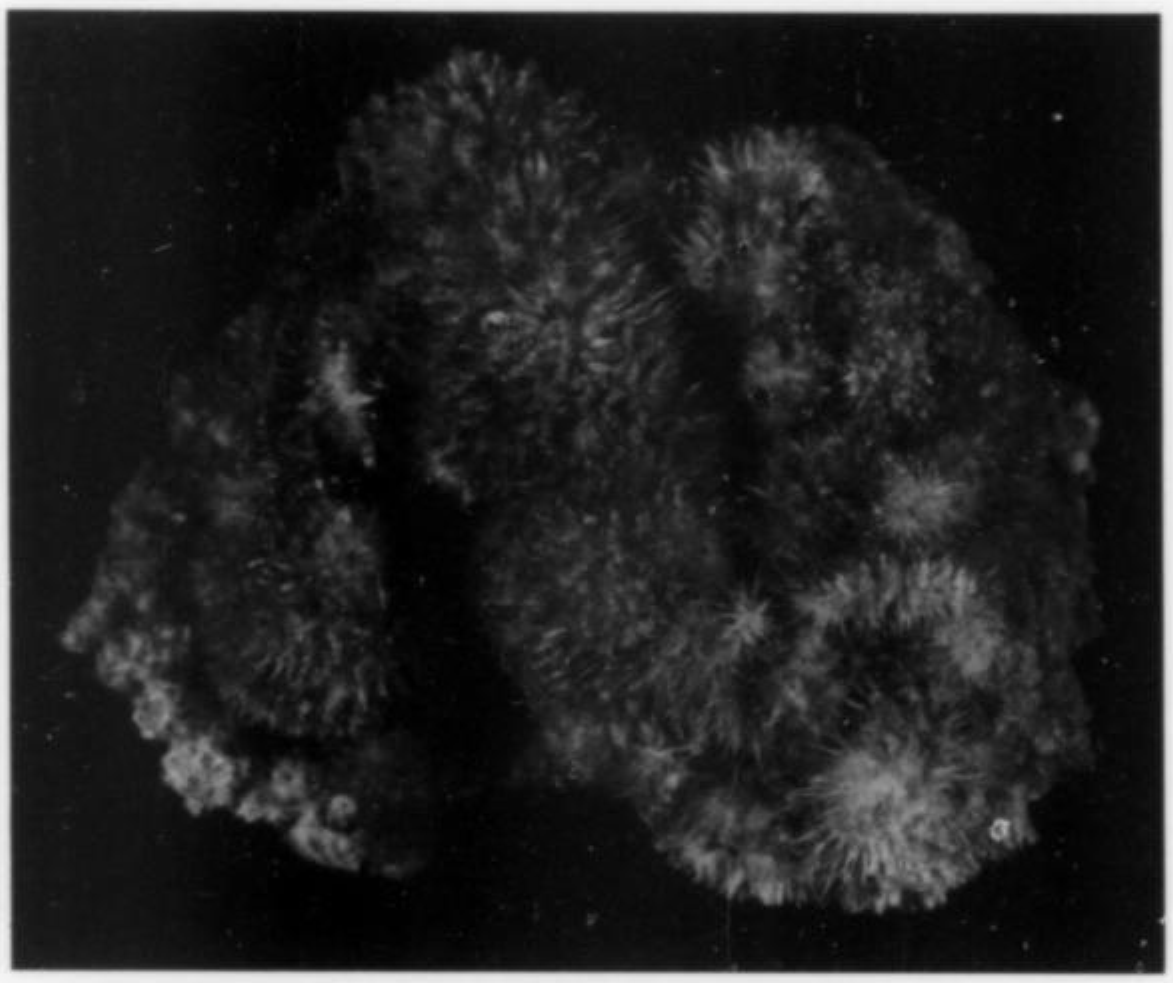

Figure 7. **A mass of alunogen covered by halotrichite crystals collected from the Stayton mine. Sample is pale tan in color and measures 8 cm across. G. Dunning specimen and photo.**

MINERALS

Alunogen $Al_2(SO_4)_3 \cdot 18H_2O$

Alunogen masses composed of fibrous aggregates cover the pyrite-rich walls of the Stayton mine. Silky subhedral crystals of halotrichite often coat the alunogen, resulting in attractive specimens.

Barite $BaSO_4$

Barite occurs as thin, tabular crystals with quartz in the Yellow Jacket mine and in the gossan of a prospect on Mariposa Peak (Bailey and Myers, 1941), but it is nowhere abundant.

Botryogen $MgFe^{+3}(SO_4)_2(OH) \cdot 7H_2O$

Dark orange-red, anhedral masses and subhedral crystals of botryogen occur as fracture fillings in the Stayton mine associated with minor cinnabar and pyrite. Some partial crystals show a short prismatic habit with abundant striations.

Cervantite $Sb^{+3}Sb^{+5}O_4$, **Stibiconite** $Sb^{+3}Sb_2^{+5}O_6(OH)$

White to pale yellow cervantite with lesser amounts of bright yellow

Figure 8. **A mass of snow-white halotrichite crystals from the Stayton mine. Sample is 12 cm in length. G. Dunning specimen and photo.**

Figure 9. **A vug containing radiating stibiconite pseudomorphs after stibnite, pale orange in color, from near the Stayton portal. Collected in 1987. Crystals are up to 1 cm long. G. Dunning specimen and photo.**

stibiconite occur throughout the stibnite veins of the district in the upper oxidized zones. Pockets of needle-like stibnite from the Stayton mine often have been either partially or completely replaced by bright yellow stibiconite and generally make attractive specimens. Bailey and Myers (1941) list both cervantite and stibiconite from the district.

Cinnabar HgS

Cinnabar is found in nearly all of the district mines as coatings or crusts filling open spaces along fracture surfaces. Some crusts are deep purple-red and crystalline; however, the cinnabar is usually bright red and locally has been called "paint." At the Comstock mine bright red cinnabar was found replacing quartz, chalcedony and opal in the silica-carbonate rock (Davis and Jennings, 1954).

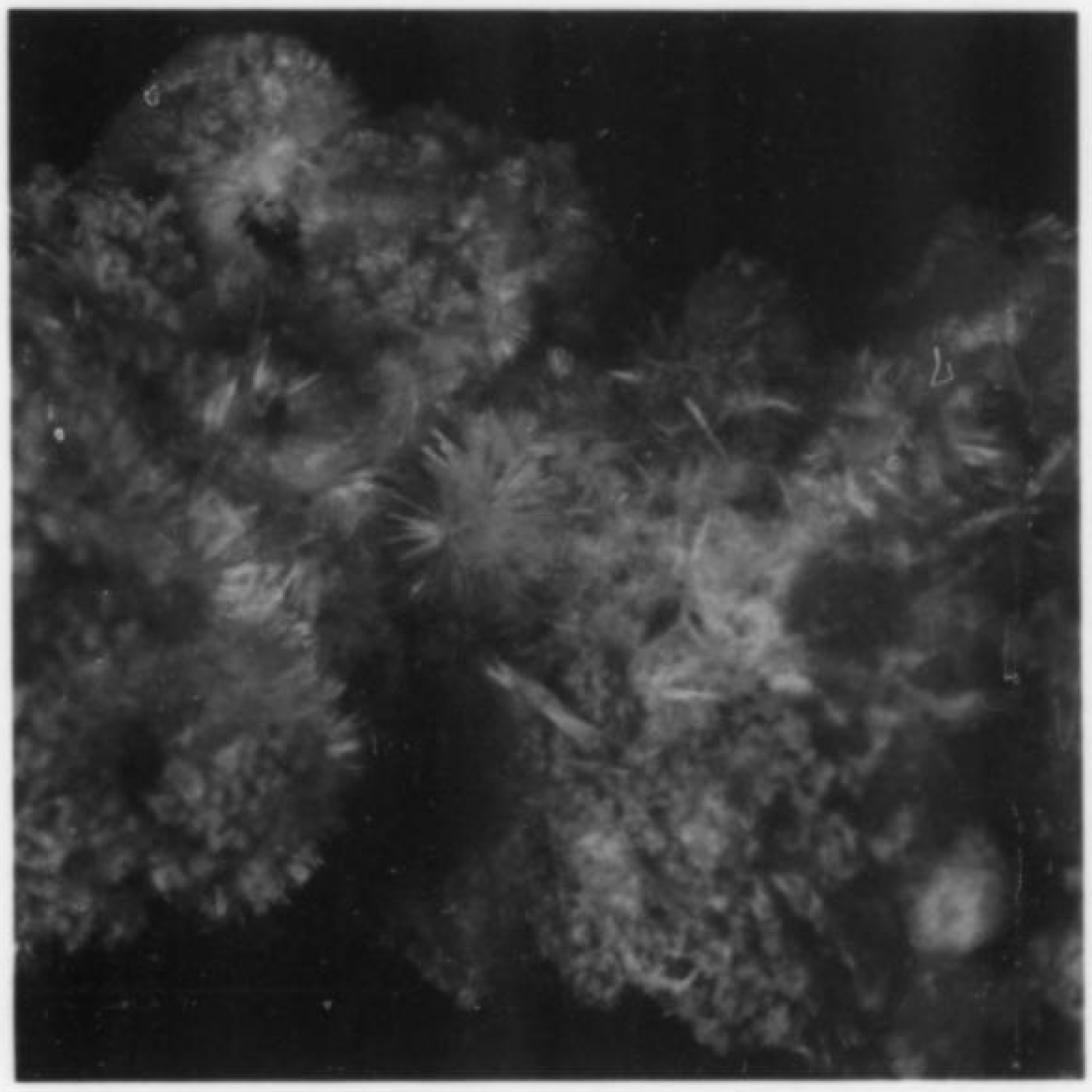

Figure 10. **Stalactitic mass of fibrous halotrichite, 1.2 cm wide and pale tan in color, collected from the ceiling of the Stayton mine. G. Dunning specimen and photo.**

Copiapite $(Fe,Mg)Fe_4^{+3}(SO_4)_6(OH)_2 \cdot 20H_2O$

Sulfur-yellow to golden yellow microcrystalline masses of copiapite, some containing aluminum, occur coating both alunogen and halotrichite in the Stayton mine.

Epsomite $MgSO_4 \cdot 7H_2O$

Secondary incrustations of epsomite, in long, tapering, hairlike needles, occur in both the Yellow Jacket and Stayton mines.

Gypsum $CaSO_4 \cdot 2H_2O$

White, fibrous gypsum has been reported as rare from both the Yellow Jacket and Stayton mines (Bailey and Myers, 1941).

Halotrichite $Fe^{+2}Al_2(SO_4)_4 \cdot 22H_2O$

Fine samples of halotrichite, composed of radial aggregates of acicular crystals, occur on the mine walls of both the Yellow Jacket and Stayton mines. The color varies from an off-white to pale brown.

Jarosite $KFe_3^{+3}(SO_4)_2(OH)_6$

Bailey and Myers (1941) report rare, yellow-brown colloform crusts of jarosite in a few of the antimony veins in the district.

Marcasite FeS_2

Marcasite, associated with pyrite, K-feldspar and clays, occurs in the silicified zones adjacent to most faults in the district (Bahia-Guimaraes, 1972).

Melanterite $FeSO_4 \cdot 7H_2O$

Bright green stalactites of melanterite cover the mine walls of the Yellow Jacket and Stayton mines where mine waters are abundant.

Mercury Hg

Small amounts of native mercury were noted with metacinnabar at the Comstock mine (Bahia-Guimaraes, 1972).

Metacinnabar HgS

Massive metacinnabar has been reported partially replaced by cinnabar at the Comstock mine (Bailey and Myers, 1941; Bahia-Guimaraes, 1972).

Pyrite FeS_2

Pyrite is present in all the district mines but is particularly abundant in the Stayton mine. Much of it occurs as small cubes or pyritohedrons in vein quartz that is older than the antimony mineralization; however, some has been shown to be younger (Bailey and Myers, 1941).

Senarmontite Sb_2O_3, **Valentinite** Sb_2O_3

Both senarmontite and valentinite occur as oxidation products of stibnite in the shallow parts of the veins, especially in the Stayton and Yellow Jacket mines (Bailey and Myers, 1941). Samples of stibnite-bearing quartz breccia collected in 1987 from below the Stayton mine portal were found (using SEM) to contain minute, sharp crystals of senarmontite lining hollow cores of oxidized stibnite crystals. Several groups of acicular valentinite crystals were also noted attached to the outer surface of the pseudomorphs.

***Figure 11.* SEM photo of a stibiconite pseudomorph after stibnite with small needles of valentinite, 0.04 mm in diameter. G. Dunning specimen and photo.**

Stibnite Sb_2S_3

The quartz breccia veins containing both massive and crystallized stibnite were first discovered about 1870 by early miners in the area. These veins are relatively conspicuous on the hills because of their higher resistance to weathering compared to the volcanic rocks. Eakle

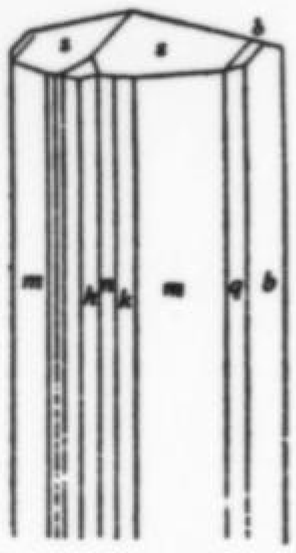

***Figure 12.* Crystal drawing of stibnite from the Stayton district (Eakle, 1908).**

(1908) first examined many of the crystallized specimens and identified the forms {010}, {130}, {110}, {310}, {210}, {430}, {113}, {4.5.12} and {102}. These crystals were identified as being from the Blue Wing, Stayton, Alta, Gleason and Shriver mines (Hanks, 1884; Crawford, 1894; Irelan, 1890). No mention was found in these early reports of the fine crystals recovered from the Ambrose mine, which are the most prominent in collections today. Possibly the Ambrose may have been either the Alta or Gleason mine and later renamed, a common practice with ownership changes.

Stibnite pockets are common in the quartz breccia of the Quien Sabe and Stayton mines; they usually contain radiating groups of bright steel-gray acicular crystals up to 3 cm in length. Cureton, as mentioned, found many crystals 5 to 15 cm in length at the Quien Sabe mine. These crystals are commonly bent and twisted. Oxidizing solutions have penetrated some of these cavities and replaced these crystals with either stibiconite or cervantite.

The most impressive stibnite crystals have come from the Ambrose mine, located near the northern part of San Benito County. Individual crystals up to 10 cm were found, although the average is about 5 cm. These crystals vary from a bright steel-gray to a dark gray in color, the latter resulting from surface oxidation. Striations are quite common on all crystals, and many are bent and twisted.

***Figure 13.* Stibnite group, 5 cm, showing slightly twisted crystals, from the Ambrose mine. Smithsonian specimen from the Carl Bosch collection, #B5870, acquired by Bosch in 1897.**

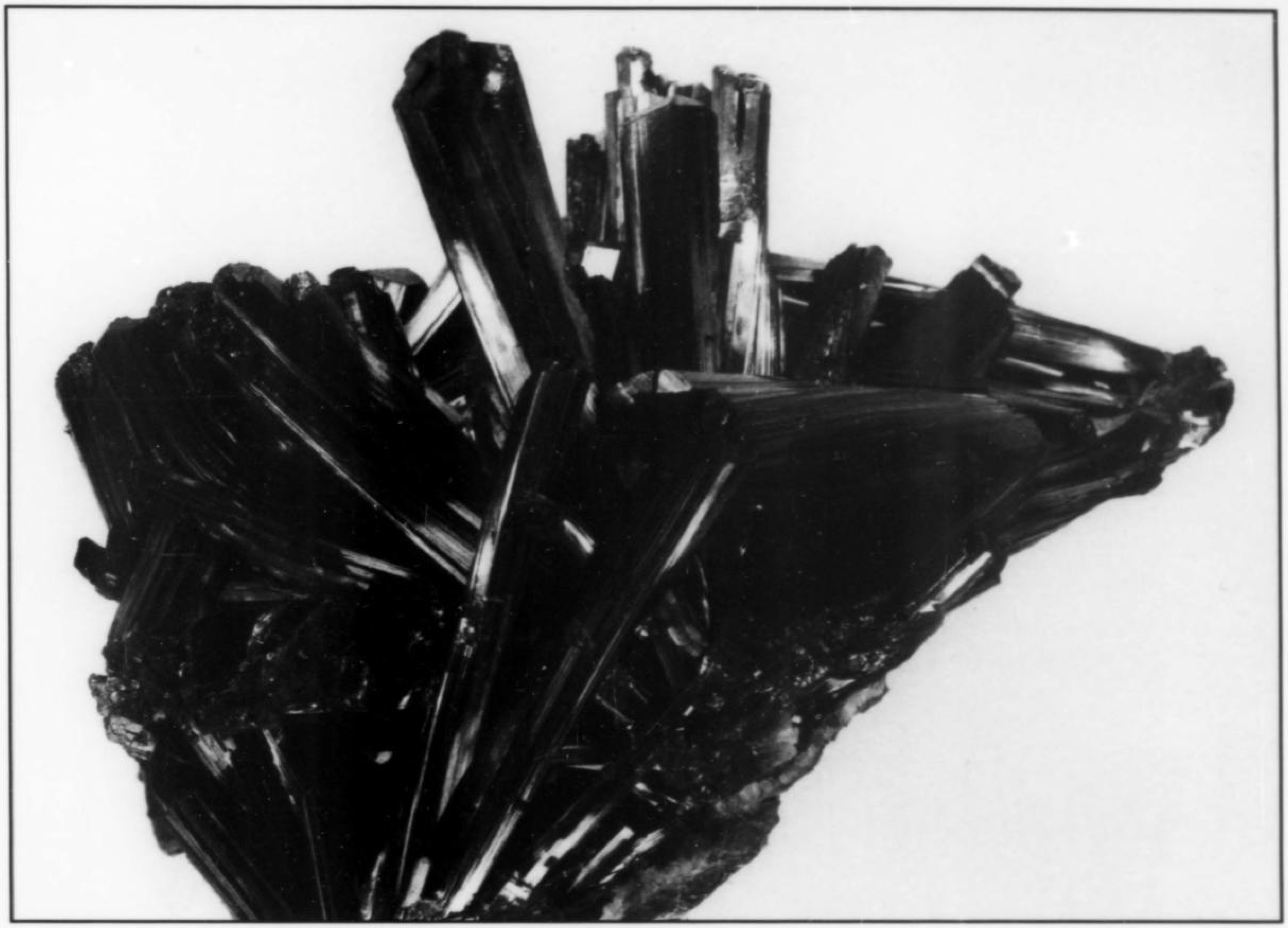

Figure 14. **Stibnite group, 7 cm across, showing twisted crystals from the Ambrose mine. Smithsonian specimen from the Frederick Canfield collection, #C258-1.**

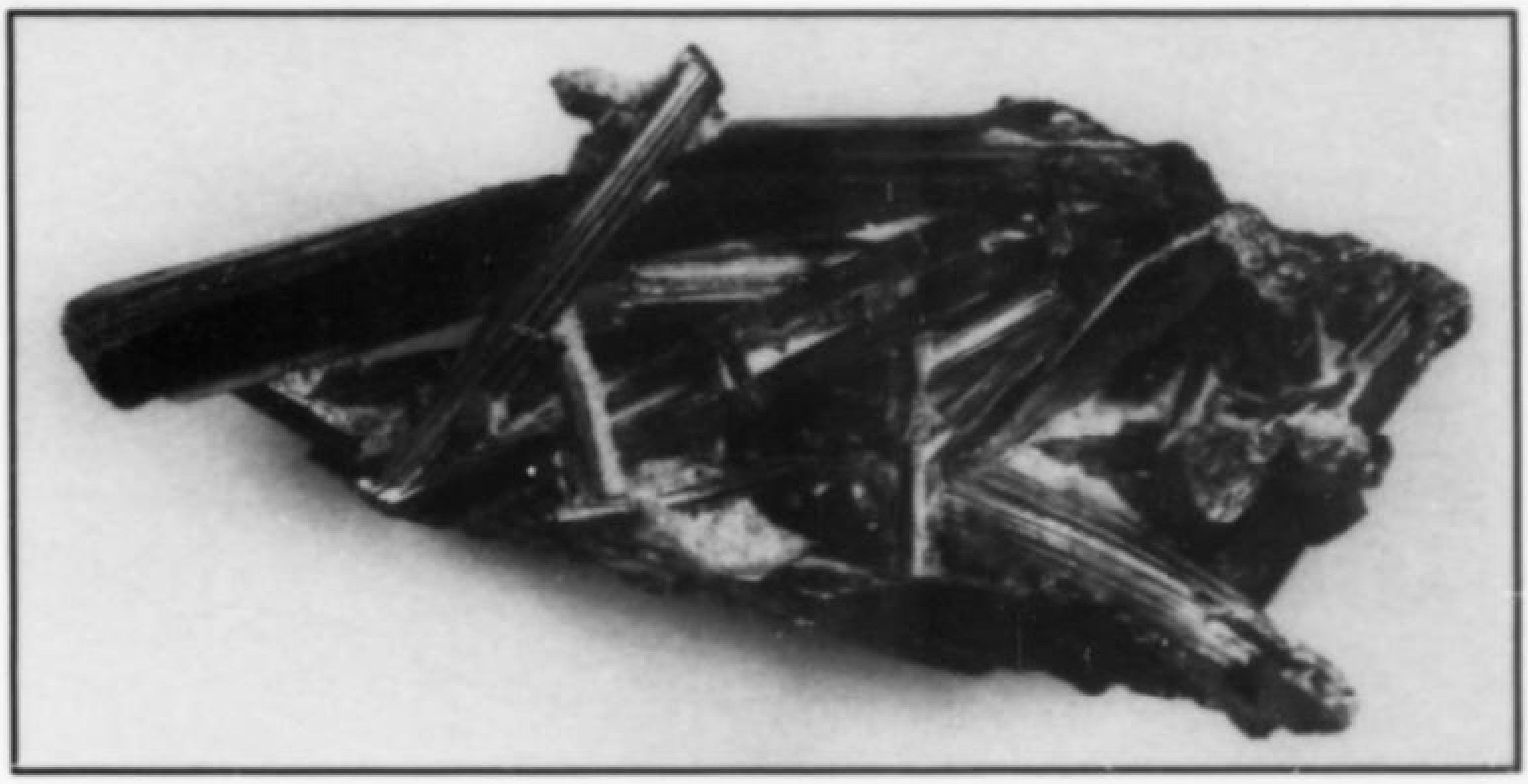

Figure 15. **A complex group of bright, twisted crystals, 4 x 7 cm, with abundant striations. Ambrose mine. G. Dunning photo; A. L. McGuinness specimen.**

Fractured stibnite crystals have been found coated with cinnabar in mines of the central and eastern parts of the district. Bailey and Myers (1941) reported jet-black velvety coatings of stibnite needles, which may have been of supergene origin, deposited on cinnabar incrustations in the Stayton mine.

Small amounts of gold and silver have been reported from the antimony ores of the district, especially the Shriver mine (Irelan, 1890). Analysis of drill cores of the Quien Sabe antimony mine, which is just south of the Stayton mine, has yielded gold values between 0.01 and 0.07 ounces per ton. John Dalton of Hollister reports $70-per-ton gold ore in the stibnite veins just southeast of the Stayton mine (personal communication, 1987).

Gold is generally not uncommon in association with stibnite in antimony deposits. Palache *et al.* (1941) reported traces of both gold and silver in many stibnite analyses. Shannon (1918) cites substantial gold in the stibnite ore of the Stanley mine, Idaho.

Sulfur S

Minute sulfur crystals occur with antimony oxides on stibnite in several of the district mines, especially the Stayton (Bailey and Myers, 1941).

DISCUSSION

The paragenetic relationship between the antimony and mercury ores has been studied by Bailey and Myers (1941) and Bahia-Guimaraes (1972) using both field and petrological techniques. They found that all gradations exist between (1) veins with only antimony (Am-

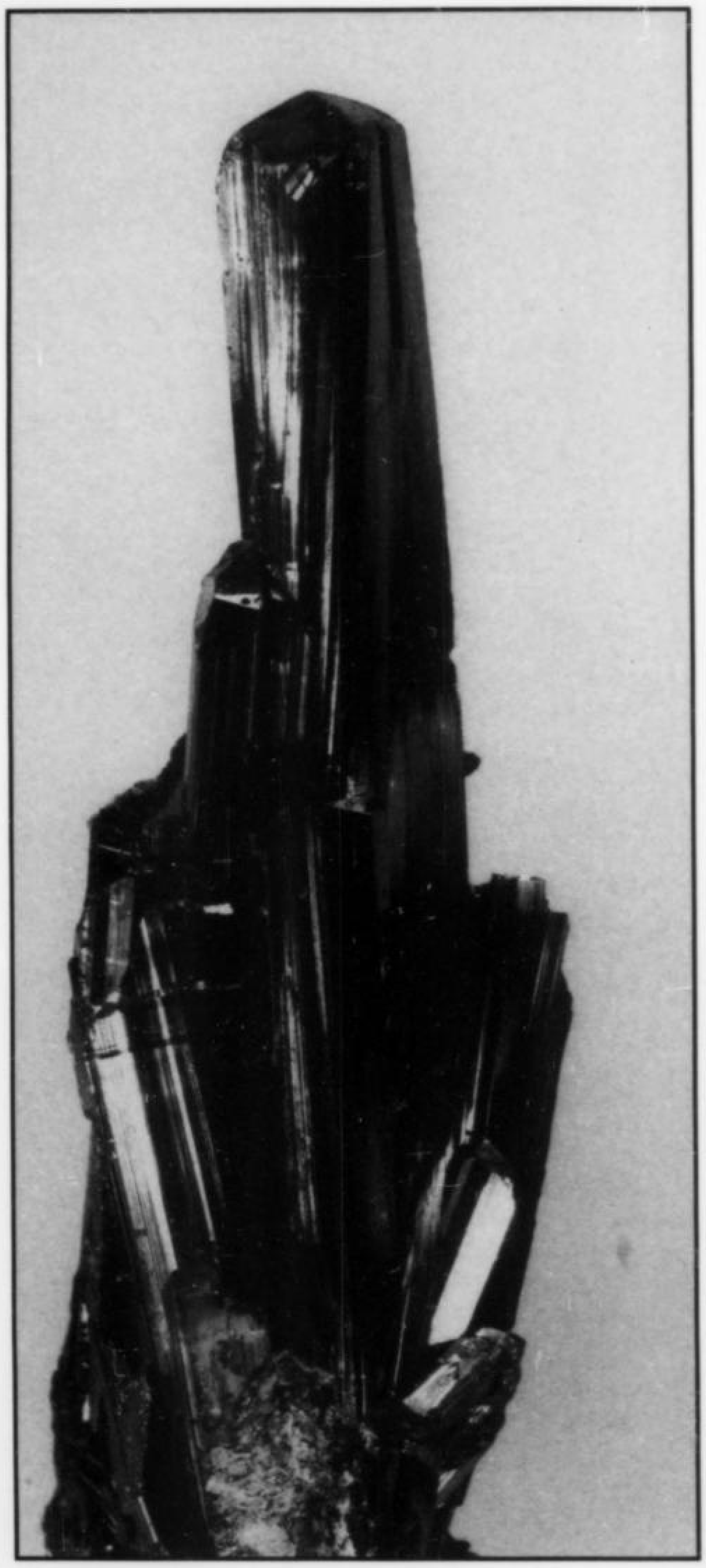

Figure 16. **Stibnite group, 7 cm tall, from the Ambrose mine. Smithsonian specimen from the Frederick Canfield collection, #C258-1.**

Figure 17. **Stibnite group, 8.9 cm across, from the Ambrose mine. Los Angeles County Museum of Natural History specimen #20194.**

brose mine), (2) deposits with both antimony and mercury (Gypsy and Stayton mines), and (3) mercury deposits with no antimony (Mariposa mine). Antimony and mercury deposition occurred during several successive stages; some stages were separated by periods of fracturing, and in others the transitions were gradational. The mineral composition of each vein was probably dependent on whether the vein was open during early, middle or late stages of ore deposition.

Although the mineralized area is surrounded by numerous igneous intrusive bodies, Bailey and Myers (1941) found no direct genetic relationship between them and the veins. The antimony veins were found to be later than at least some of the intrusive andesitic bodies, as was indicated by the presence of a vein along a fault in one of the larger plugs. In the vicinity of Antimony Peak, two faults in andesitic extrusive rocks contain antimony veins, which suggest that part of this mineralization followed and was contemporary with faulting. This field evidence indicates that the earliest mineralization in the area was later than all igneous activity except possibly the emplacement of the intrusive rhyolite.

The mercury deposits consist of cinnabar-filled fractures in and near portions of the antimony veins in the southeastern part of the district. Isolated deposits not related to antimony veins occur west of Mariposa Peak and also in the northwestern corner of the district. These are (1) fractured antimony veins with later cinnabar encrustations and impregnations, (2) cinnabar fillings in otherwise unmineralized fractures in basalt, and (3) cinnabar veins and replacements in silica-carbonate rock derived from serpentine. The cinnabar ore was localized along faults in all of the principal mines. Within the fault zones cinnabar commonly coats closely spaced, nearly vertical late fractures.

Experimental work by Learned (1966) on the four systems SiO_2-Na_2S-H_2O, HgS-SiO_2-Na_2S-H_2O, SiO_2-Na_2O-H_2O and HgS-Sb_2S_3-Na_2S-H_2O provides evidence that mercury-bearing minerals were probably precipitated from ascending solutions at temperatures between 25° and 275°C, and at pressures between 1 and 60 bars. The most likely mercury carrier was considered to be an alkaline sulfide solution.

Bahia-Guimaraes (1972) concluded from field evidence and the work of Learned (1966) that the antimony and mercury mineralization of the Stayton district was introduced by alkaline solutions in an environment similar to hot spring deposits. Formation of K-feldspar in the alteration zone of the basaltic-andesites indicates that the hydrothermal solutions had a high K^+/H^+ ratio. The experimental work of Learned (1966) also suggests an explanation for the separation in both time and space of the antimony-mercury deposits, on the basis of mutual solubilities of cinnabar and stibnite.

The suite of minerals comprising the antimony-mercury deposits with the exception of K-feldspar and post-mine sulfates, is consistent with formation at low temperature and pressure conditions near or at the surface.

CONCLUSION

At the time this study was begun, the authors were unaware of the many fine stibnite crystal groups that had been preserved during the early mining years. Some initial inquiries with major museums and universities resulted in an abundance of information on stibnites of the Stayton district. For instance, it was learned that many fine, crys-

***Table 1.* Location, description, and history of some Stayton district stibnite specimens.**

***Location:* American Museum of Natural History**

#693	*Ambrose mine*. A divergent group of stout, terminated crystals, 2.5 x 2.5 x 5 cm, with a bluish tarnish. Longest crystal is 5 cm and slightly curved. Obtained with the C. S. Bement collection, through George English.
#694	*Ambrose mine*. A group of bright, blue-tarnished crystals, 7.5 x 7.5 cm, with the individual crystals about 3 mm thick and up to 4.5 cm long. There is some crystal damage but the specimen is quite showy. Obtained with the C. S. Bement collection, through Howell's Microcosm.
#695	*Ambrose mine*. A group of blue-tarnished crystals on a 5 x 7.5 cm matrix. The crystals, 3 mm thick x 2.5 cm long, are bent and twisted with broken terminations. Obtained with the C. S. Bement collection, through Howell's Microcosm.
#18351	*Ambrose mine*. A group of prismatic, terminated crystals, 10 x 10 cm, with the longest crystal being 10 cm long. Many of the crystals are twisted about the *c* axis. Obtained with the Lazard Cahn collection in 1917.
#18352	*Ambrose mine*. A group of lustrous to lightly tarnished crystals, 5 x 6.4 cm, with very good pyramidal terminations. Obtained with the Lazard Cahn collection in 1917.

***Location:* Bryn Mawr College Collection**

#640	*Ambrose mine*. An intergrowth of two crystals, the largest about 0.7 x 1 x 6.0 cm. The two crystals form a V shape and are coated with oxides of antimony. The surface is somewhat dull and is covered in some areas by several smaller crystals. Some terminations are evident on the longer crystals. George Vaux collection.

***Location:* Harvard University Mineralogical Museum**

#81584	*Ambrose mine*. Crystal section to 3.5 cm showing good twisting about the *c* axis but not terminated. Obtained from G. L. English, probably before 1911.
#111284	Listed only from *Hollister*. A bright mass of crystals, 2.5 x 4.5 x 7 cm showing twisting but not terminated. No source information.
#111286	*Ambrose mine*. Bright crystal group on matrix, 4 x 4 x 8 cm, well terminated and kinked but not twisted. No source information.
#119546	Listed only from *Hollister*. A single, tarnished crystal, 5.5 cm, with minor crystals, partly coated with oxides. Shows twisting well. Purchased from the Grace Deaborn collection in 1980.

***Location:* Los Angeles County Museum of Natural History**

#666	Labeled *Lone Tree mine* but most likely the *Ambrose mine*, it is a mass of bladed crystals, 3.0 x 5.6 x 8.6 cm, but not terminated. Associated with possible stibiconite and quartz. No source information.
#12218	Labeled *Lone Tree mine* but most likely the *Ambrose mine*. A fine specimen composed of several lustrous, striated crystals with a few terminations, 3.7 x 3.7 x 8.75 cm. Largest crystals about 0.5 x 1.0 x 7.5 cm. No source information.
#20194	*Ambrose mine*. A fine group of lustrous, striated, terminated crystals, some typically curved. Size of group 6.4 x 10.0 x 11.4 cm with the largest crystal measuring 0.5 x 0.6 x 4.0 cm. From the Lazard Cahn collection, Northwestern University.
#24036	Listed only from *Hollister*. A mass of divergent crystals, mostly dull, with a few terminations, 8 x 8.4 x 12 cm. Largest crystals are about 0.6 x 0.8 x 6 cm. Acquired in 1983.

***Location:* Lyman House Memorial Museum, Hilo, Hawaii**

Ambrose mine. Consists of a matrix plate, 5 x 11 x 13 cm, with an intergrown group of crystals up to 3 cm covering most of the matrix. The reverse side consists of a badly damaged spray of crystals, the largest being 6 cm in length. No source information.

***Location:* National Museum of Natural History, Smithsonian Institution**

#B1020-1	*Ambrose mine*. An excellent group of very clean and bright crystals in a V form, each crystal about 2.5 cm long. The crystals are twisted and well terminated. Acquired with the Carl Bosch collection (see Roe, 1978, for a description of the Carl Bosch collection).
#B5870	*Ambrose mine*. An excellent group of crystals 5 cm long and 1.2 cm wide. Obtained in 1897.
#B19704	No mine name, but probably from the *Ambrose mine*. A large group of crystals, 5 x 11.4 x 12.7 cm, with individual crystals from 2.5 to 3.8 cm with good terminations. Acquired with the Carl Bosch collection.
#C258-1	*Ambrose mine*. A good group of very twisted and terminated crystals, 3.8 x 4.4 x 7.0 cm. Acquired with the Frederick Canfield collection.
#R376-1	No mine name, but probably from the *Ambrose mine*. A tree-shaped group, 3.2 cm, very bright and partially encrusted. Acquired with the Washington Roebling collection.

tallized, "old time" stibnites have been preserved from the Ambrose mine; these are some of the finest specimens ever collected in the United States. Furthermore, we believe this is the first locality found in the United States for crystallized stibnite, followed shortly thereafter by the White Caps mine, Manhattan, Nevada (see Gibbs, 1985).

The distribution of these specimens is quite interesting in that they all became part of private collections prior to the turn of the century or shortly thereafter. For example, a number of Stayton district stibnites were included in the private collections of distinguished collectors such as George Vaux, Lazard Cahn, Carl Bosch, Washington Roebling, George English, Frederick Canfield and C. S. Bement. Many stibnite specimens from these important collections are preserved today in prominent museum and university collections.

During our visit in 1963, the majority of the district mines were either completely inaccessible or so dangerous as to make exploration unadvisable. Today there are no prospects for future collecting in the district, as all of the mines have been completely sealed to prevent entry. However, for those interested in examining some of the "old time" stibnites from the Ambrose mine, a number of institutions are listed which have some fine examples on display.

***Table 2.* Minerals of the Stayton district, Hollister, San Benito County, California.**

Native Elements	***Sulfates***
Mercury	Alunogen
Sulfur	Barite
Sulfides	Botryogen
Cinnabar	Copiapite
Marcasite	Epsomite
Metacinnabar	Gypsum
Pyrite	Halotrichite
Stibnite	Jarosite
Oxides and Hydroxides	Melanterite
Cervantite	
Stibiconite	
Senarmontite	
Valentinite	

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A. L. McGuinness made available stibnite specimens for study and photos. Gary Moss provided a color slide of a stibnite on display at Bryn Mawr College, courtesy of Rock Currier. Richard Erd kindly provided some important reference material and reviewed a draft of the paper.

The authors also acknowledge the cooperation and interest of the following in providing important information and illustrations on the Stayton district stibnites in their respective institutional collections: John Sampson White (Smithsonian Institution), Joel A. Bartsch (Lyman Museum), Demetrius Pohl (American Museum of Natural History), Carl Francis (Harvard) and Robert Middleton (Los Angeles County Museum of Natural History).

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"PSEUDOLEUCITE" PSEUDOMORPHS FROM RIO DAS OSTRAS, BRAZIL

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INTRODUCTION

Some outstanding "pseudoleucite" pseudomorphs have been discovered recently in the state of Rio de Janeiro (Menezes and Tubbs, in press). These are comparable in quality with the best specimens from Cascata, the only previous recorded Brazilian occurrence. Cascata is located in the large Poços de Caldas alkali massif (Guimaraes and Ilchenko, 1954).

According to Johannsen (1958), the phenocrysts are pseudomorphs after original leucite and are usually altered to a nepheline-microperthite-analcime mixture called "pseudoleucite." The pseudoleucites are composed of aggregates of orthoclase in irregular grains and, more often, radiating prisms. Interstitially there is a comparatively small amount of nepheline, usually as irregular patches but rarely as prismatic crystals. The cores of the original leucite crystals are filled with analcime or, occasionally, a weakly doubly refracting zeolite as yet unidentified. In some cases the pseudoleucites are zoned, containing a potassium-rich alkali feldspar and exhibiting a trapezohedral form.

Pseudoleucite-bearing rocks are found in areas characterized by alkali magmatism (Gupta and Yagi, 1980). These are rock types known as tinguaites, with rare outcrops of shonkinite and monchiquite rocks as lava flows, dikes and intrusions.

LOCATION

The occurrence lies east of the small town of Rio das Ostras (Oyster River) and east-southeast of Morro de São João Mountain, in Casimiro de Abreu township. This is near the mouth of the Rio das Ostras, on the southwestern slope of a long hill which adjoins the Praia Brava (Wild Beach) to the south. The outcrop is located about 20 meters above the left bank of the river (at coordinates x = 198.6 and y = 7506.5 on the Barra de São João map, SF-24-Y-A-IV-1, IBGE 1963).

Access is via a 600-meter dirt road which branches off the Amaral Peixoto highway (RJ 106) at km 150, immediately past the Rio das Ostras bridge; the turnoff is marked by a service station.

OCCURRENCE

The pseudoleucite pseudomorphs occur in a highly weathered, lenticular dike about 2 meters wide. It strikes N40°W, cropping out over a length of about 20 meters. The wall rock is a weathered granitic gneiss intersected by narrow, parallel dikes of fine grained alkalic rocks.

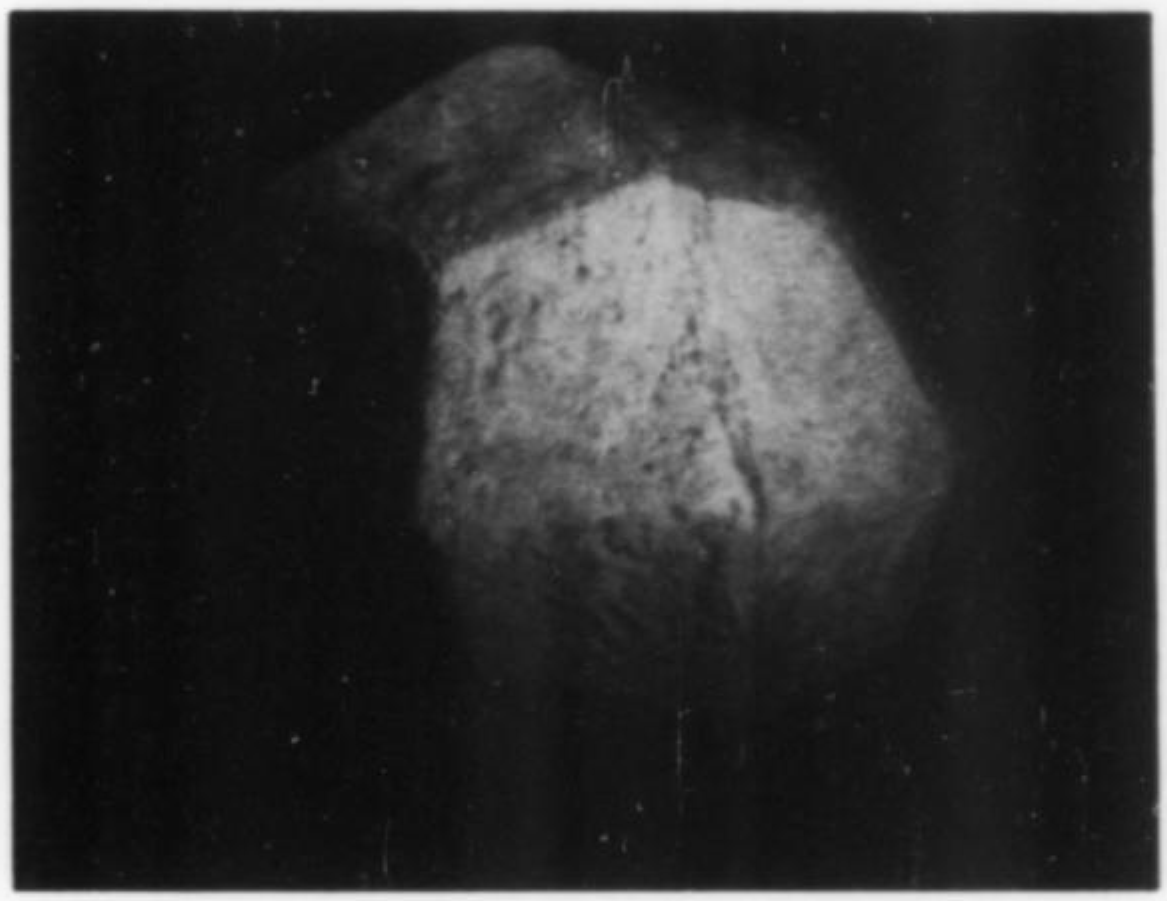

Figure 1. **Large pseudoleucite pseudomorph, 4.5 cm in diameter.**

The rock in which the pseudoleucite occurs is reported to be a trachyte (Barra de São João geologic map, Reis and Licht, 1982). Further information regarding unaltered pseudoleucite-bearing rocks of the nearby Morro de São João alkali massif can be found in Reis and Valença (1979). Valença and Edgar (1979) published a review of the pseudoleucite occurrences in the state of Rio de Janeiro.

PSEUDOMORPHS

Although none of the original leucite remains, even in the cores, alteration has left the original crystal shape unchanged. The trapezohedron is the only form observed. Distorted growth has, in some cases, resulted in five to seven-sided faces.

The pseudomorphs are whitish, yellowish white, pale pink, yellowish pink and pinkish beige in color, always in pale hues. Some are stained by iron oxides.

Singles represent about 90% of all the pseudomorphs found, the others being twins and groups. The majority of the singles are between 1.6 and 2.5 cm in diameter, with examples under 1 cm being rare.

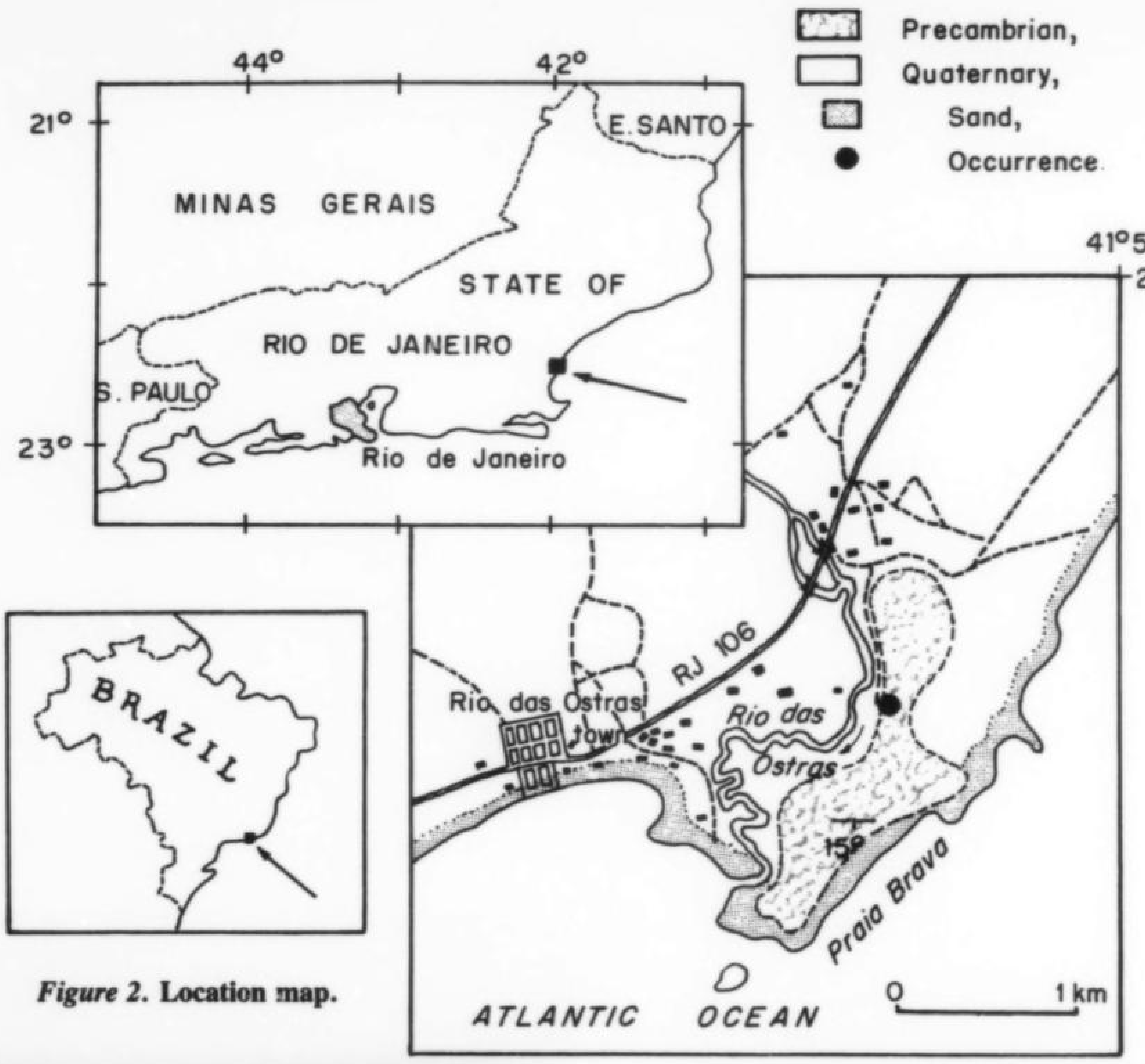

Figure 2. **Location map.**

Figure 3. **The outcrop.**

Larger ones up to 4 cm are not uncommon. A few show offset fracturing or dislocations, and others tend to split into two nearly equal halves. These weakened planes are relicts of the recrystallization process, and are sometimes invaded by brown or yellow veinlets visible on the faces of the pseudomorphs.

Alteration of the original leucite was probably related to a late hydrothermal stage during dike emplacement. It produced mainly aluminum hydroxides (including gibbsite) as well as kaolinite containing impurities leached from other minerals. In outcrops where kaolinite is the main constituent, the pseudomorphs are whitish to pale yellow in color with somewhat rounded edges. Such samples are easily destroyed or damaged by immersion or soft washing. On the other hand, specimens in which aluminum hydroxides are predominant (pinkish to pale beige in color) are stronger and will withstand washing and vigorous brushing. Because these latter pseudomorphs retain their sharp edges they are most preferred by the collector. Some pseudomorphs have pitted faces or show a thin lustrous coating of an unidentified mineral.

Collecting at the site is currently unrestricted, but housing construction is scheduled for the site in the future.

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The Highland Bell mine, Beaverdell, British Columbia

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For the past 80 years the Highland Bell mine in southern British Columbia has produced high-quality native silver specimens, well-crystallized silver sulfides and silver sulfosalts.

INTRODUCTION

The Highland Bell mine is today an amalgamation of several mines in the Beaverdell silver camp, Greenwood mining division, British Columbia. The mines are located on Wallace Mountain just a few kilometers east of the town of Beaverdell. The town is situated on the Westkettle River, 48 km north of the Canada-U.S. boundary. Access is via Highway 33 south from Kelowna. The mine area is covered by Topographic Series Map Sheet 82E/6E.

HISTORY

The earliest mining activity in the area took place in 1860 when placer gold was discovered at Rock Creek, about 45 km south of Beaverdell. During the summer of that year Rock Creek had approximately 500 prospectors working the local gravels, but the rush soon slowed as the miners drifted northwards to the more lucrative gold fields of the Cariboo. During the late 1880's and early 1890's lode-mining became dominant in southern British Columbia and the major mining camps of Slocan, Nelson, Phoenix, Rossland and Sullivan were established. The successful development of the lode-gold deposits at Rossland, about 100 km southeast of Beaverdell, led to a flurry of prospecting along the Westkettle River. Silver-bearing quartz veins were located on Wallace Mountain. All the major claims were staked by 1897 and the town of Beaverdell was established shortly thereafter. Many of these claims, including the Bell, Highland Lass, Sally, Rob Roy, Wellington and the Beaver became important silver producers on Wallace Mountain.

In 1900, the first mineral production on Wallace Mountain came from the Sally mine, owned by the Vancouver and Boundary Creek Development and Mining Company. All ore was hand-sorted and transported by wagon or sleigh some 80 km southeast to Midway, the nearest railway link to a smelter. Robertson (1902), the Provincial Mineralogist for British Columbia, reported that this selected ore averaged 150 ounces of silver per ton and 7% lead. The best ore sampled by Robertson reached a high of 322 ounces of silver per ton and 13% lead. The Sally mine and the adjoining Rob Roy mine continued operations until 1941, producing just under 2 million ounces of silver.

The potential of Beaverdell mining camp improved in 1913 when the Kettle Valley Railway completed its line to Beaverdell. Ore could then be shipped directly by rail to the smelter at Trail, British Columbia.

Although the ore was rich, the veins were narrow and had frequently been disrupted by extensive faulting. J. D. Galloway (1914), an assistant mineralogist for the British Columbia Minister of Mines, reported, "In the early stages of prospecting much time and money was wasted in looking for the faulted veins in wrong directions. . . . This excessive faulting of the veins has proved a great drawback to the

Figure 2. **The Sally mine and bunkhouse in 1915 (from Reinecke, 1915).**

Figure 1. **Location map.**

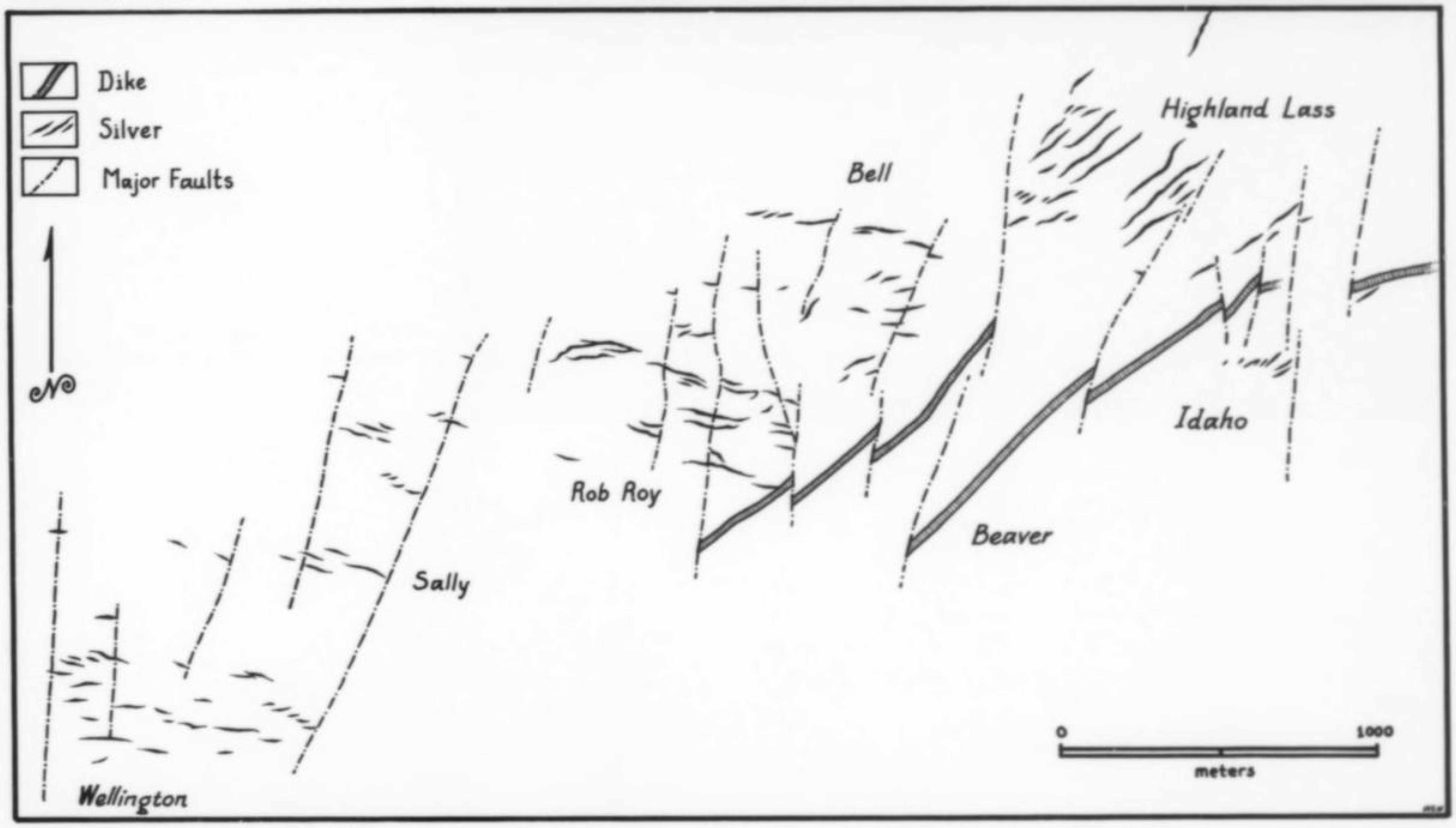
district, as, in many instances, the owners have been forced to cease operations before the faulted veins were picked up again."

The Bell mine, immediately adjacent to the Sally-Rob Roy mine, was first worked in 1909, but continuous production did not begin until 1916. At this time the claim was leased to Bob Perry who worked it for one summer, earning $4,600 for his single car-load of ore. He was paid an additional $6,000 when he transferred his lease to Duncan McIntosh. McIntosh, with his understanding of the faulted nature of the orebodies, immediately took on an experienced mining engineer as a partner. Working with a crew averaging 25 men, McIntosh worked the Bell mine from 1916 to 1930. According to mine records, the Bell mine produced over 3.5 million ounces of silver between 1916 and 1936. (According to Angus Davis (1949), Bob Perry continued to live in Beaverdell throughout this time and became more and more embittered as production from the claim continued to mount.) The faulted nature of the veins always brought surprises. Freeland (1925) notes that McIntosh was blasting out tree stumps to level some ground for a tennis court when a high-grade vein was discovered. The tennis court was forgotten and two or three car-loads of ore were removed until the vein was found to be cut off by a fault. Further investigations showed the vein was the faulted continuance of a vein they had already mined out from below.

In 1930, R. B. and F. Staples and associates obtained control of the Bell mine and the adjoining Highland Lass, forming a new company, the Highland Bell Limited. In 1946, Leitch Gold Mines Limited obtained control of Highland Bell Limited as well as the Sally mine. In 1970, the Highland Bell mine became a member of a group of

Figure 3. **Beaverdell Camp of the Highland Bell Ltd., 1946 (from Staples and Warren, 1946).**

Figure 4. **Simplified geology showing dike, faults and silver-containing veins (after Kidd and Perry, 1957).**



mines controlled by Teck Corporation.

For 50 years all of the mines at Beaverdell had been hand-sorting their ore and shipping only the highest grade directly to the smelter. In 1950, a 50-ton per day mill was built at Beaverdell to concentrate the lower grade ores which had been stockpiled since the mines first opened. Since 1950 the production from this mill has been increased to 120 tons per day. As of 1975 the mines of Wallace Mountain had produced about 30 million ounces of silver (Verzosa and Goetting, 1973) and have probably yielded about 5 million ounces since then.

GEOLOGY

Reinecke (1915) has provided the most detailed and comprehensive geological study of the area.

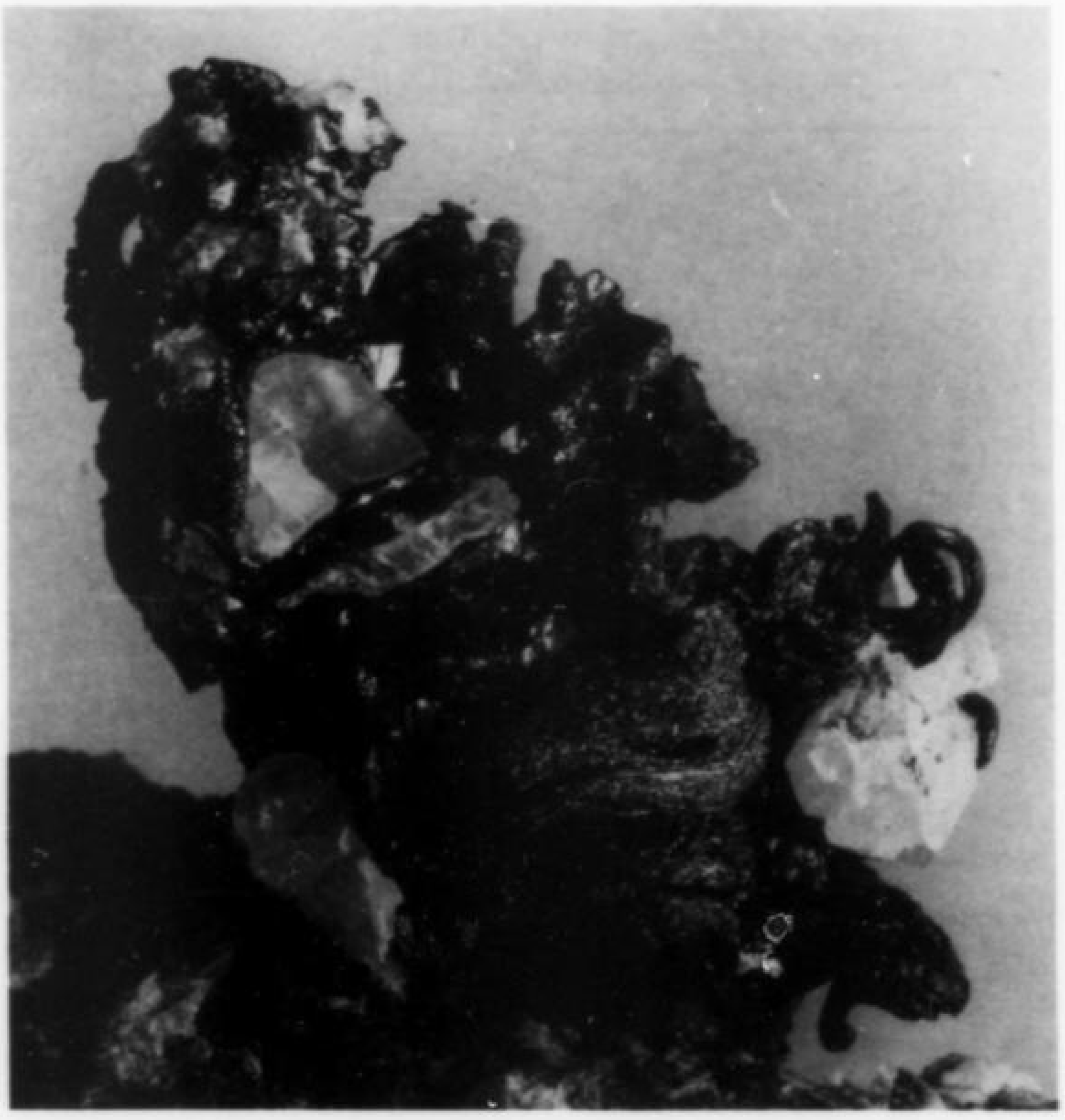
Rocks in the Beaverdell area are of three main types: (1) the Beaverdell porphyritic quartz monzonite stock, (2) the Westkettle quartz diorite batholith, and (3) the Wallace formation of tuffs and lavas. In addition, porphyritic andesite dikes cut the area. The diorite is the host rock for the orebodies.

Silver lodes occur in brecciated quartz veins and stockworks concentrated in a mineralized zone approximately 6.4 km long from east to west. The veins vary from a few centimeters to 1.8 meters in width, averaging around 28 cm. Much of the vein breccia has been replaced by quartz, and well-rock propylitization is extensive near the lodes. Sulfides occur as replacements of quartz and as irregular disseminations in wall rock. Lean and rich zones alternate, and the veins are cut by innumerable offset faults. White (1949) remarked, "Rarely has ore been followed in any direction for more than a few tens of feet without offsetting or other interruption." Corrected for offsets, however, some mineralized veins are continuous for nearly 200 meters.

At the Bell mine the veins and stringer lodes strike northeasterly

Figure 5. Silver with acanthite, 4 cm, from the Highland Bell mine.

Figure 6. Acanthite on wire silver with calcite, 3 cm, from the Highland Bell mine. Provincial Museum of Alberta specimen G83.26.1.



in the plane of a set of faults. Acanthite, freibergite, pyrargyrite, polybasite and native silver comprise the silver ore, accompanied by pyrite, sphalerite and galena. Gangue minerals include quartz, calcite and minor fluorite.

Veins in the Beaverdell area have been followed to a depth of over 600 meters, and show no change in mineralogy or ore grade with depth. Minor secondary ore occurs within 100 meters of the surface but, for the most part, the silver mineralization is considered primary (Kidd and Perry, 1957).

MINERALS

Silver

Excellent specimens of native silver were recovered from the Highland-Bell area during the early years of mining and again in the 1950's. Arborescent and wire silver having a reddish yellow tarnish was found growing from the surface of massive and crystallized acanthite, polybasite and rarely, pyrargyrite. Specimens of silver weighing up to 1 kg were recovered, particularly from the upper levels where secondary minerals had formed in open spaces (Staples and Warren, 1945). Fine wire silver has been collected in recent times as well. However, much of the silver in the mine occurs only as flakes and disseminations.

Sulfides

Sphalerite, pyrite and galena are frequently associated with the silver minerals. Acanthite typically occurs as jet-black masses and slender, prismatic crystals clearly precipitated as acanthite and not argentite (Staples and Warren, 1945). Some of the finest argentite crystals were collected from the 8th level. Staples and Warren (1946) commented that perhaps one in every 20 vugs encountered contains acanthite crystals.

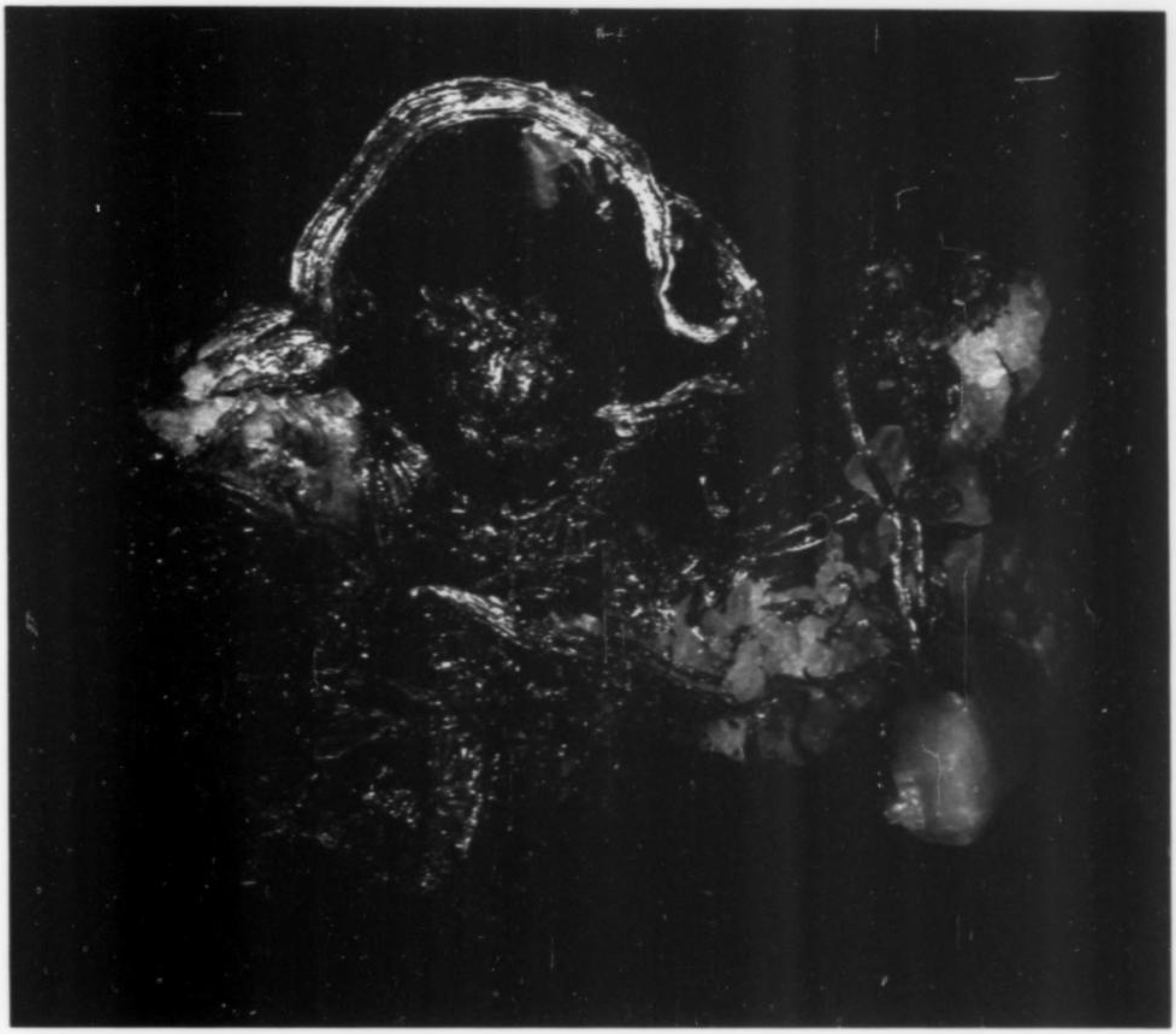


Figure 7. Silver specimen, 4.5 cm, from the Highland Bell mine.

Figure 8. Wire silver, 3.5 cm tall, from the Highland Bell mine. Rod Tyson collection.

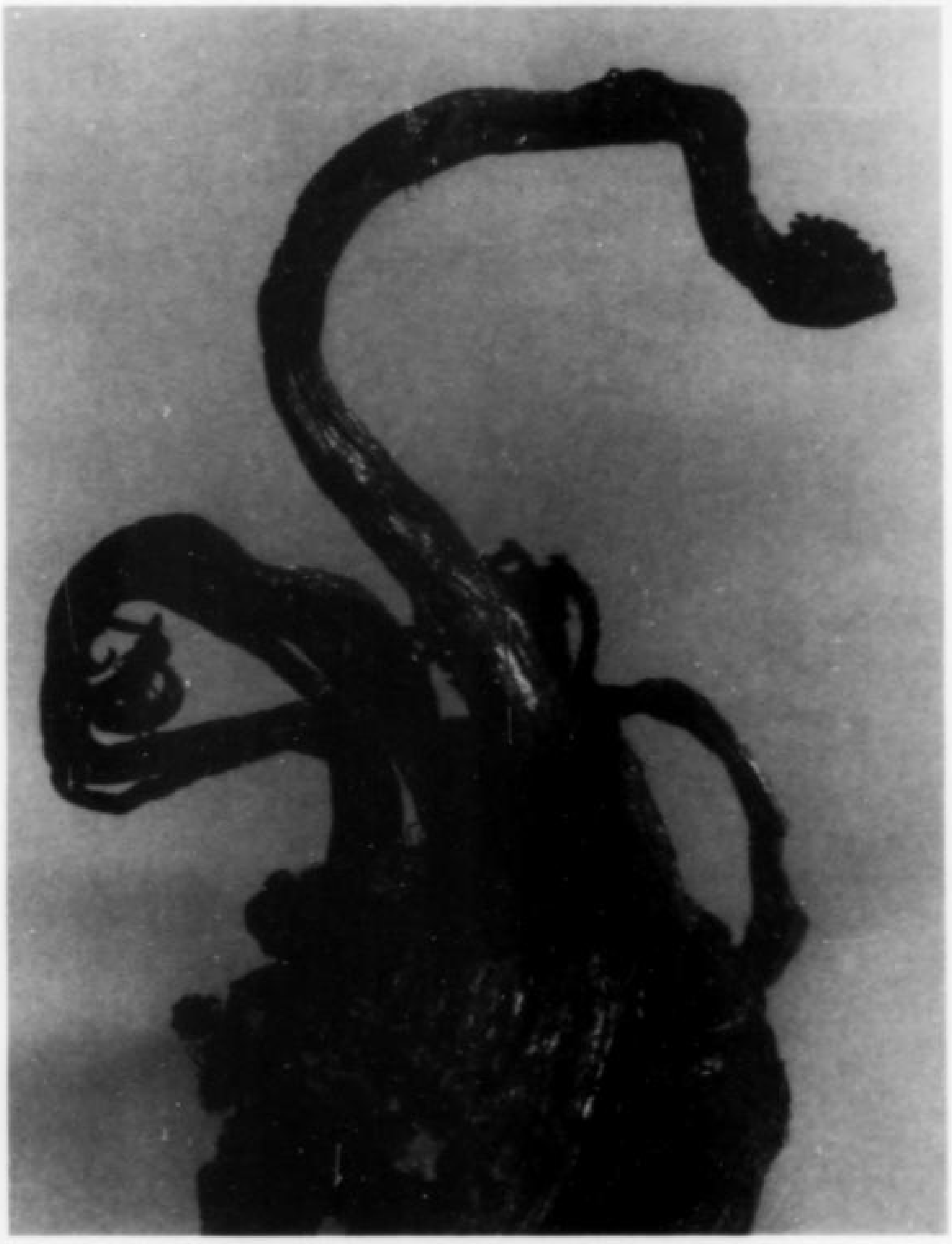


Table 1. **Vein minerals reported from the Highland Bell mine.**

Acanthite	Ag_2S
Arsenopyrite	FeAsS
Beudantite	$PbFe_3(AsO_4)(SO_4)(OH)_6$
Calcite	$CaCO_3$
Chalcopyrite	$CuFeS_2$
Dyscrasite	Ag_3Sb
Fluorite	CaF_2
Freibergite	$(Ag,Cu,Fe)_{12}(Sb,As)_4S_{13}$
Galena	PbS
Gold	Au
Hematite	Fe_2O_3
Molybdenite	MoS_2
Polybasite	$(Ag,Cu)_{16}Sb_2S_{11}$
Pyrargyrite	Ag_3SbS_3
Pyrite	FeS_2
Quartz	SiO_2
Scheelite	$CaWO_4$
Silver	Ag
Sphalerite	(Zn,Fe)S
Stephanite	Ag_5SbS_4
Sternbergite	$AgFe_2S_3$

Sulfosalts

A number of extremely fine crystallized sulfosalts were recovered in the 1930's and again in 1967. Michael Evick (then a mineralogy curator at the Vancouver City Museum) suggested to the late mineral dealer Ed McDole that he visit the Highland-Bell mine. This was in the 1950's, and McDole was able to purchase many fine pieces.

Figure 9. **Wire silver, 2 cm, from the Highland Bell mine. Pr›vincial Museum of Alberta specimen G83.21.28.**

Another group of specimens surfaced in 1967, including sharp, 1.2-cm crystals of stephanite and sternbergite, and 6-mm pyrargyrite crystals, all collected on the 2900 level. Polybasite crystals to 5 mm were obtained by McDole, and Evick later obtained crystals to 1 cm from Alex Bell, one of the original claim owners. These crystals have the form of hexagonal plates with beveled edges, and are high in lead. Crystals of acanthite to 6 cm, and silver wires 5 mm across, accompany the polybasite. Freibergite was found as crystals and disseminated grains enriched somewhat in zinc (Staples and Warren, 1946). These and other minerals reported from Highland Bell are listed in Table 1.

COLLECTING

The Highland Bell is an active underground operation and collecting there is prohibited. Very little silver has escaped to the dump, and recent mining has not been taking place in vuggy areas. Nevertheless, future exploration in the upper levels may locate more near-surface veins where well-crystallized specimens would be more plentiful.

ACKNOWLEDGMENTS

The writers are indebted to the following individuals: Mr. B. Goetting of Teck Corporation for historical and background information; Ulrich Matern for his field assistance; Michael Evick, Glenbow Museum, for specimens used in this study; Rod Tyson, for specimens used in this study; Dennis Hyduk and Bob Plummer, Provincial Archives for specimen photography; Colleen Steinhilber for assistance with the manuscript; and J. Fortier and Philip H. R. Stepney for administrative support.

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THE BLUE BALL MINE, GILA COUNTY, ARIZONA

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The Blue Ball mine in Gila County, Arizona, has yielded several hundred thousand nodules of azurite and azurite-malachite measuring from 6 mm up to 7.5 cm in size. Many of the nodules are geodes lined with attractive drusy azurite and fibrous malachite.

LOCATION

The Blue Ball mine is located in the Summit mining district in Gila County (Welty *et al.*, 1985). The mine is approximately 3 miles south of Miami and can be reached by 4 miles of dirt road. It is in the *Pinal Peak, Arizona* 7.5 minute quadrangle in section 7, T1N, R15E, and is shown as a shaft and tunnel labeled "Azurite Mine." The mine is currently under claim by Chuck Withers of Globe, Arizona.

HISTORY

Although local collectors say that the locality was known in the 1930's, and many collectors and dealers in the Phoenix area possessed nodules in the 1950's, the first documented record seems to be the location of the mine shown on the quadrangle map in 1964, and a mention of the locality by Sinkankas in that same year. The workings shown on the topographic map are completely collapsed and there is no record of when they were active or who was involved. From 1968 to 1975, several copper companies including Inspiration Consolidated Copper Company, Miami Copper, and Phelps Dodge drilled extensively in this area in search of copper.

From 1978 to 1982 active mining for nodules by George Sites and Jack Tanner produced most of the azurite and azurite-malachite specimens which are in collections today. The nodule-rich zones were mined by tunneling into the clay with a pick or broad-blade chisel. These tunnels no longer exist; the clay flows into them in a very short time. After soaking the nodules in water, Sites and Tanner used a street sweeper brush to remove the clay. A more detailed description of this operation is given in Jones (1980). The present-day operation is being conducted by Graham Sutton and Carl Barnt, who are open-pit mining for the nodules.

GEOLOGY

The general geology of the area has been described by Ransome (1905) and Peterson (1962). A detailed geological report of the Blue Ball mine area was made by Gatchalian (1975). The nodule deposit is located in a clay gouge along the Williamson fault, which is an extension of the Miami fault, a major structure in the area. In the vicinity of the Blue Ball mine, this fault splits into two parts enclosing a sheared and mineralized wedge of Pinal schist (Precambrian age) measuring about 60 x 300 meters, which dips at an angle of 25°–60° northeast. To the south is the Solitude granite (Precambrian) and to the north is Gila conglomerate (Tertiary basin fill material).

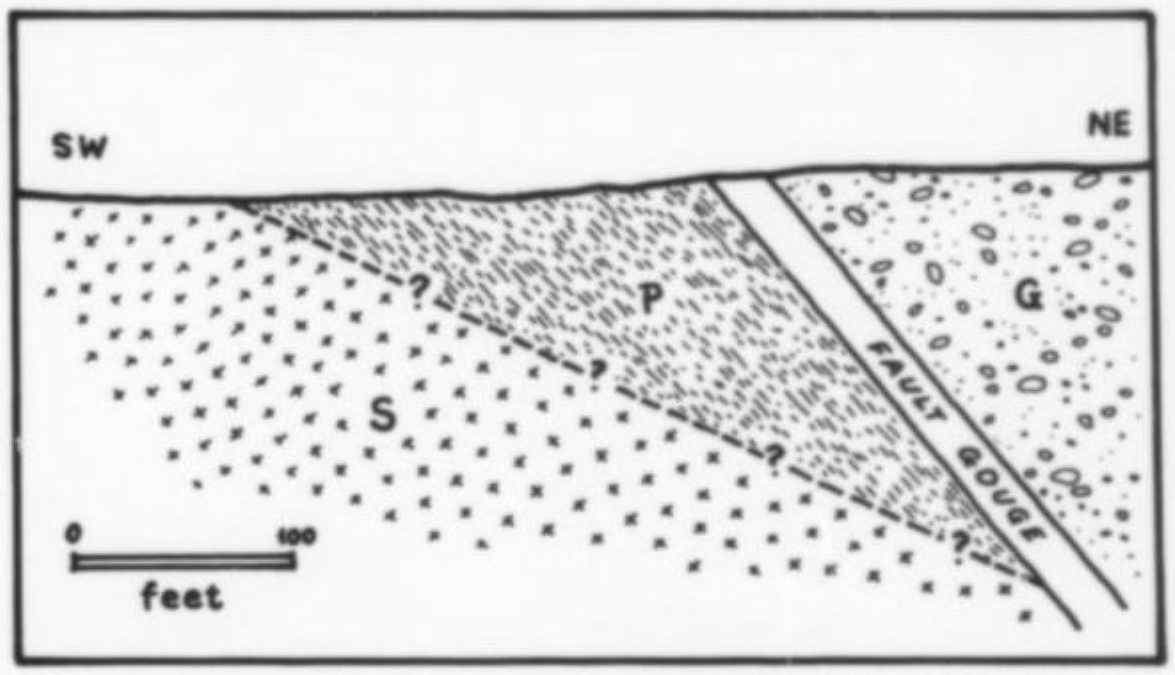


Figure 1. **Diagrammatic cross-section of the geology of the Blue Ball mine area, after Gatchalian (1975). S = Solitude granite; P = Pinal schist; G = Gila conglomerate.**

Drilling within the schist has revealed a sulfide deposit containing pyrite, chalcopyrite, chalcocite and molybdenite as close as 3 meters from the surface. This mineralization is the source of copper for the nodules. An estimated 1.7 million tons of 0.26% copper exist in this deposit (Gatchalian, 1975), but it is uneconomic at present.

MINERALOGY

A number of minerals are present at the Blue Ball mine, all of them found in the clay zone.

Azurite $Cu_3(CO_3)_2(OH)_2$

Azurite is the most common mineral collected at the mine. It commonly occurs as solid nodules which have been used as a source of blue pigment. Many of the nodules, however, are hollow and are lined with drusy azurite crystals. These sharp prismatic crystals are up to 5 mm in size, but most are less than a millimeter in length.

Figure 2. **Blue Ball mine in 1982. Ray Grant photo.**

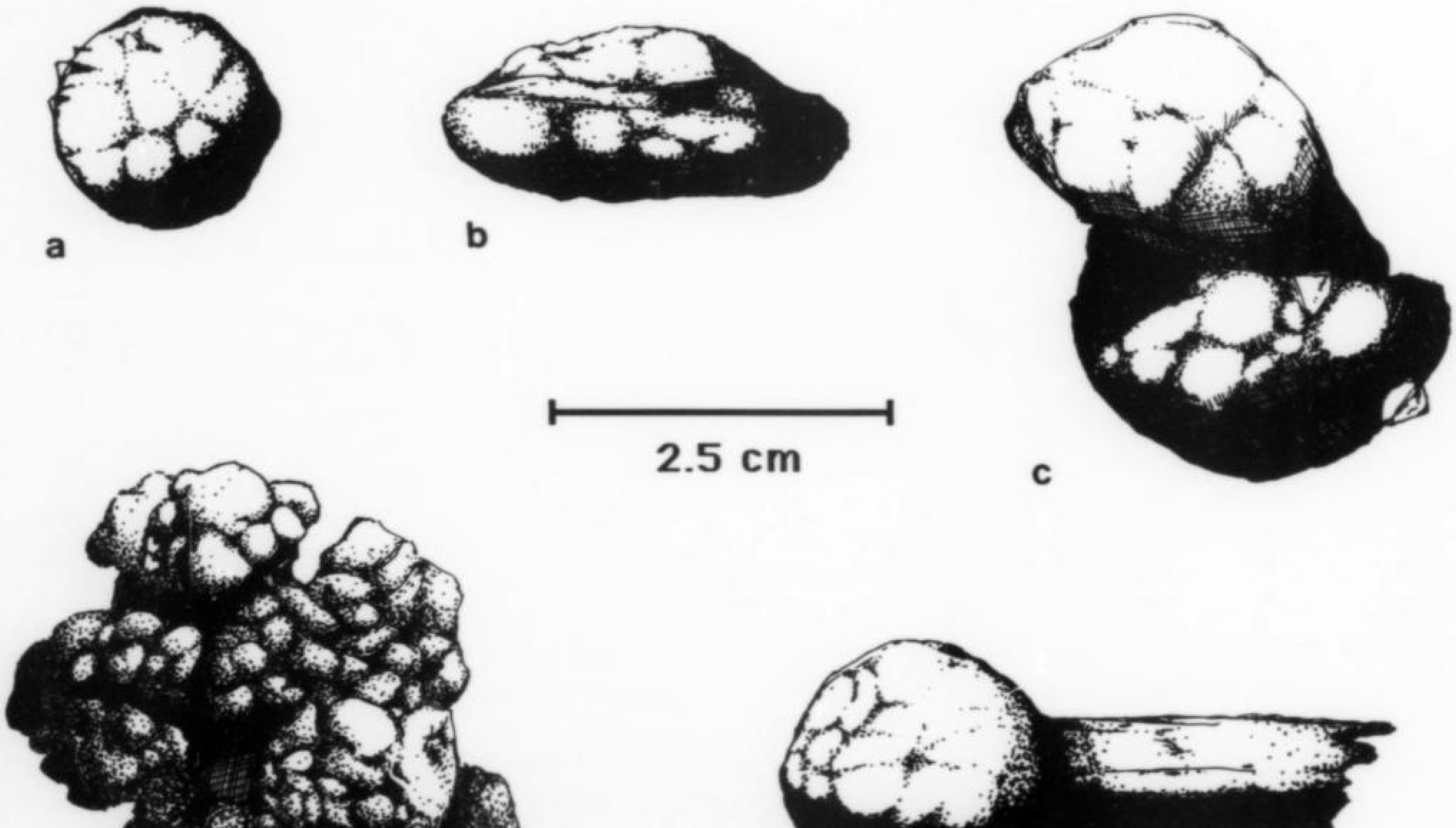
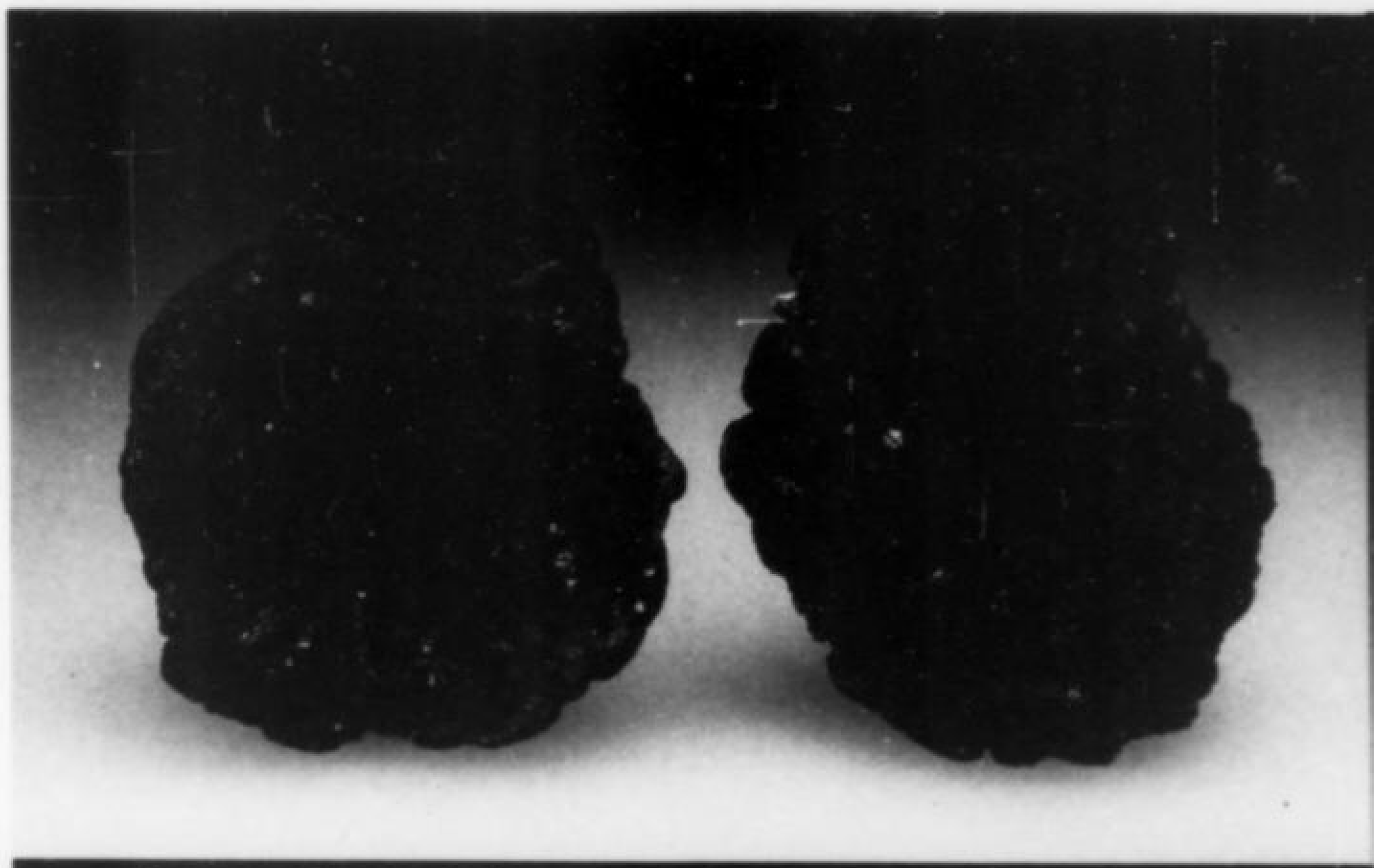


Figure 3. **Nodule morphology: (a) spherical, (b) flattened, (c) faulted, (d) irregular, (e) with a tail; drawing by Ken Esra.**



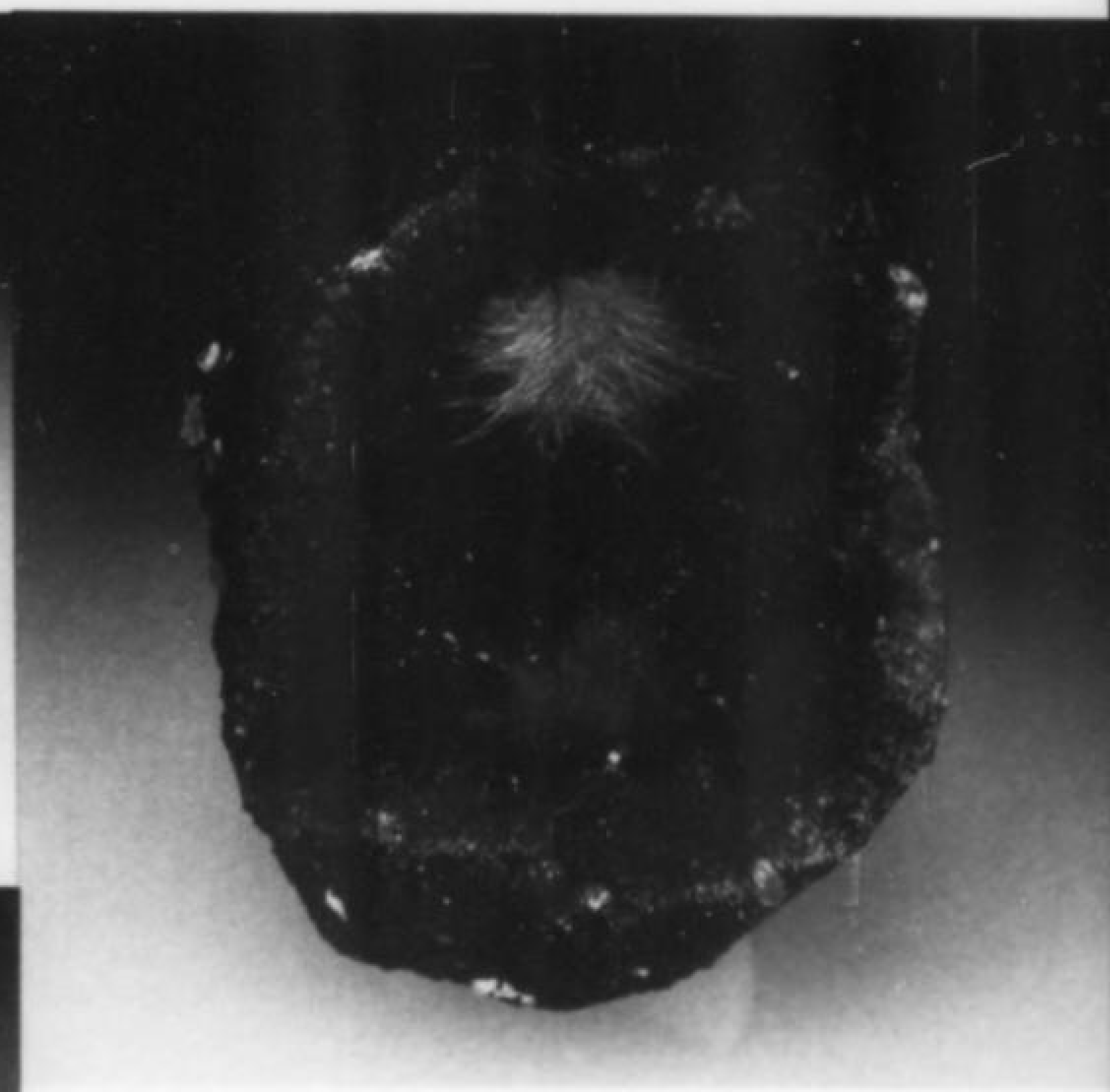


Figure 4. **Fibrous malachite in an azurite geode, 3.1 cm high. Jim Vacek collection; photo by Jeff Scovil.**

Figure 5. (upper left) **Hollow azurite nodule, 4.8 cm high. Jim Vacek collection; photo by Jeff Scovil.**

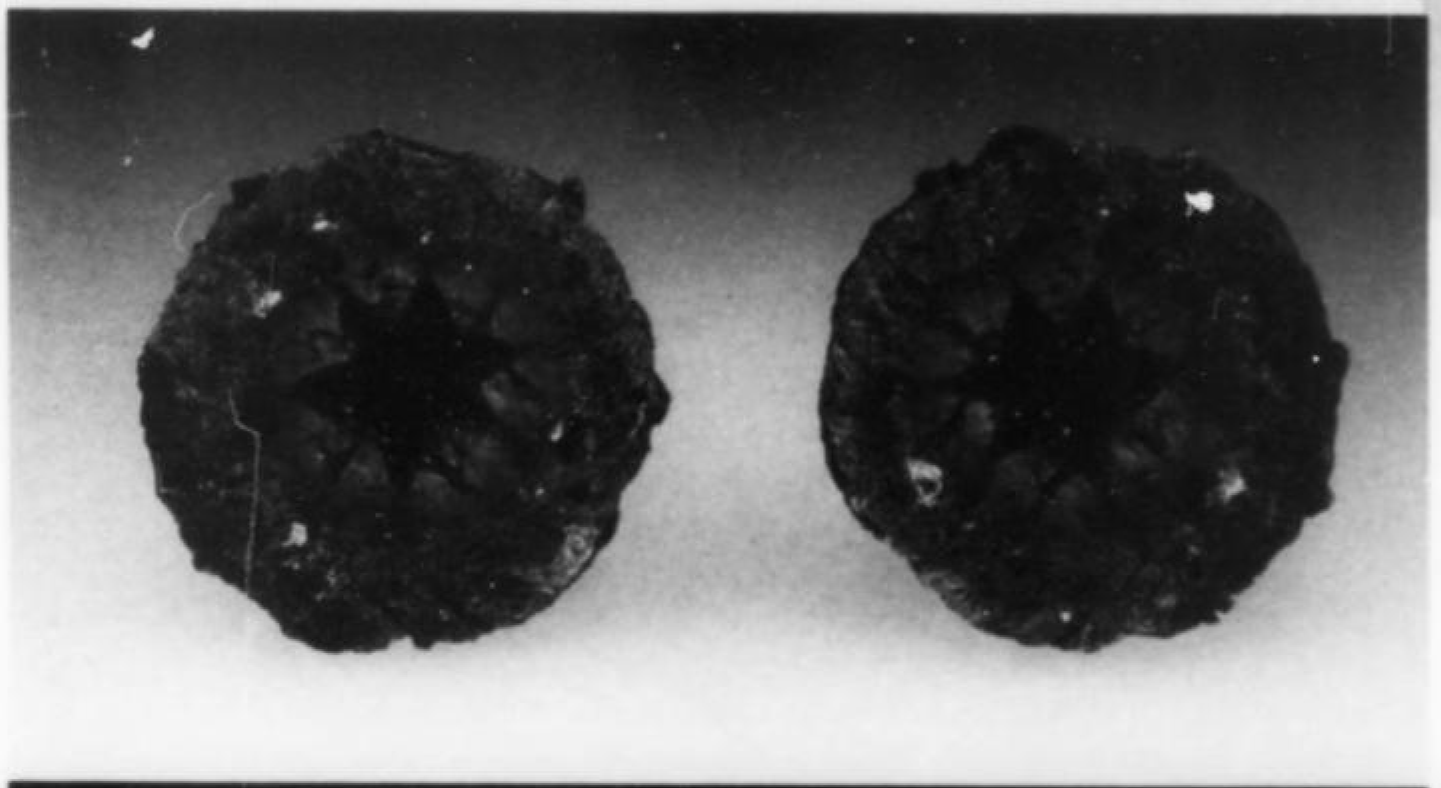


Figure 6. **Azurite-malachite nodule with alternating azurite and malachite, 2 cm high. Jim Vacek collection; photo by Jeff Scovil.**

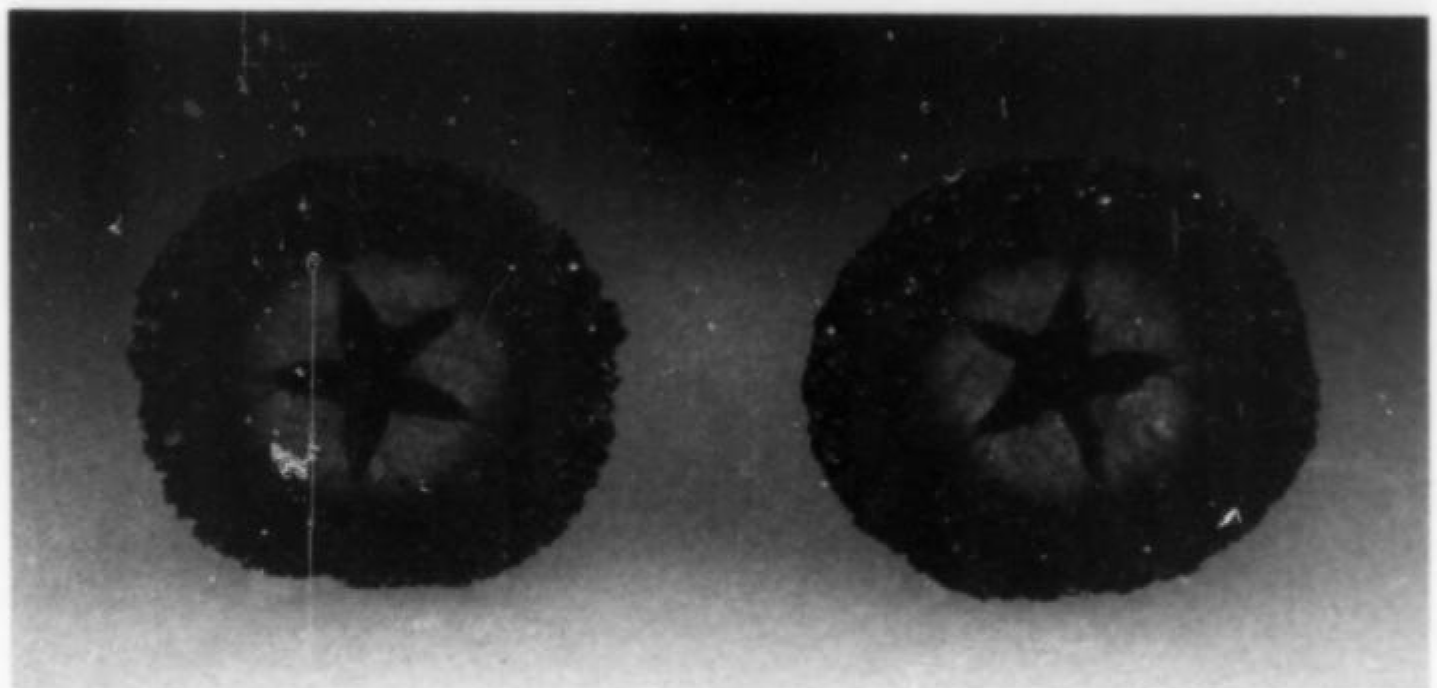


Figure 7. **Nodule with shrinkage cracks forming a star, 1.1 cm high. Jim Vacek collection; photo by Jeff Scovil.**

Barite $BaSO_4$

Small, clear, flat prismatic crystals of barite up to 6 mm in size are present in a few of the hollow azurite nodules.

Cuprite Cu_2O

A very few malachite octahedrons up to 3 mm in size were found on the outside of some azurite nodules. It is assumed that these are altered cuprite crystals.

Clay Minerals

X-ray diffraction studies of the clay in which the nodules occur show that the clay is a mixture of kaolinite and a member of the smectite group.

Gypsum $CaSO_4 \cdot 2H_2O$

Gypsum is also found as nodules and crystals in the clay. The crystals may be several centimeters long; they are colorless and transparent, and in some cases show swallow-tail twinning. The gypsum may also have inclusions of azurite and malachite.

Malachite $Cu_2(CO_3)(OH)_2$

The second most common mineral is malachite. It occurs as complete malachite nodules, and as nodules which are part malachite and part azurite. Many of these nodules show a very distinct contact between the azurite and malachite. Some have alternating bands of malachite and azurite, which indicates that conditions were such that both malachite and azurite were forming as the nodules formed. Malachite also occurs as fibers growing in the azurite geodes. In some cases, especially where the outer surface of the nodule is crystalline azurite, it is obvious that the malachite is replacing the azurite.

Manganese Oxides

Many black nodules were also recovered from the clay. An X-ray fluoresence analysis showed manganese and iron to be present. No copper was found, so these are not tenorite as they have been called by some collectors. An X-ray diffraction analysis of the nodules gave only patterns of kaolinite and quartz. As with many manganese oxides, this material seems to be poorly crystallized and has not been identified.

Figure 8. **Buckets of azurite and azurite-malachite nodules from the Blue Ball mine. Ray Grant photo.**

Quartz SiO_2

Quartz is very common as single euhedral to subhedral crystals in the clay and in the nodules. The crystals are doubly terminated with the prism almost absent, although, under magnification, a small prism can be seen; this is the typical habit of high quartz (Frondel, 1962). The crystals are up to 1.2 cm in length, are milky in color, and have rough but equant faces. These crystals were probably phenocrysts in a high-temperature dike which, except for the quartz, has been changed to clay. Several hundred meters to the west along the fault, similar quartz crystals are found loose, along with single orthoclase crystals. Some of the orthoclase crystals are carlsbad twins similar to phenocrysts found in high-temperature dikes. Granite porphyry dikes and sills were reported in this area by Peterson (1961); altered rocks at the mine were probably originally the same kind of dike rock.

NODULES

Several unique conditions exist at the Blue Ball mine which allowed the formation of the nodules: (1) The presence of the mineralized schist (the small wedge of schist seems to be the only mineralized rock along the fault in this area); (2) the post-mineralization faulting which formed the clay gouge in which the nodules are found; and (3) the presence of high-temperature granitic dikes in the area. Although the age and exact relationship of these dikes to the nodules is not known, all of the nodules have quartz phenocrysts associated with them.

The azurite and azurite-malachite nodules range in sizes from less than 6 mm up to 7.5 cm (Sinkankas, 1964). The largest nodule examined for this report was 5.0 cm. Most are roughly spherical, but some are flattened with the shorter diameter as small as half the larger diameter. Other nodules are irregular (lumpy). Other unusual shapes, which are only rarely seen, are: faulted nodules, where there has been movement along a crack through the nodule with displacement up to 1 cm, but the nodule is still held together; and flattened nodules with flat pointed tails.

Many of these nodules are hollow and lined with small crystals. These cavities have the appearance of having formed from shrinkage of the nodules. The hollow nodules are very attractive, and, in addition to their specimen interest, have been used in a wide variety of applications in the lapidary trade.

ACKNOWLEDGMENTS

I am very grateful to Jim Vacek of *49er Minerals*, Scottsdale, Arizona, who supplied the specimens examined for this paper. He has encouraged the mining of the nodules since 1978, and has the largest collection of them. Also, thanks to Jeff Scovil for the photography, Ken Esra for the drawings, and Graham Sutton for the information about the present mining activity.

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PYRITE CRYSTALS FROM SORIA AND LA RIOJA PROVINCES SPAIN

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Pyrite crystals from La Rioja and Soria have been well known in Spain for more than a century, but only in recent years have they become prominent on the international mineral market. Specimens from Navajún may well rank as the finest cubic pyrites in the world.

INTRODUCTION

The *caballero* (knight) Bernardo Perez de Bargas, in 1568, wrote as follows regarding Spanish pyrite: "It was of many colors, one golden, another silvery, forming square grains like dice next to each other in the cliff."

Perez did not give the exact locality, but his words could describe pyrite from a wide area encompassing the Sierra de la Bellanera and Sierra de Alcarama districts in Soria and La Rioja provinces.*

Pyrite has been found in Spain since ancient times, and in recent years many first-class specimens have reached public and private collections around the world. Some occurrences have been described in earlier literature (Calderón, 1910), and have been mined for specimens for at least the last 50 years. But the Soria–La Rioja area is not mentioned in most modern mineralogies (e.g., Palache *et al.*, 1944), and has become internationally known for superb pyrite from the Navajún area only since the early 1970's.

The exact locality is often given incorrectly. In some cases (White, 1984; Curto and Fabre, 1987) the locality is referred to as "Amejún"; no town of this name exists, but near the town of Armejún some small, oxidized pyrite crystals have been found. The error may be due to the similarity in names, or possibly to the dealers' desire to keep the source confidential.

The pyrite area is located in the Sierra de Alcarama and Sierra de la Bellanera, straddling the boundary between Soria and La Rioja (formerly Logroño) provinces, in northern Spain. Topography is rugged, with an elevation of about 1000 meters above sea level. The region is sparsely inhabited; some towns are deserted. During the winter months the prospects are largely inaccessible. Access to pyrite occurrences is usually via dirt roads cut by the Forest Service. With the exception of the Valdenegrillos occurrence, all prospects are situated in gullies where the pyrite-rich beds have been exposed by erosion.

*Ed. note: To pronounce Spanish locality names correctly, more or less, read "y" for "ll," "ny" for "ñ" and "h" for "j."
Barranco = ravine, *Sierra* = mountains, *Arroyo* = stream, *Molino* = mill.

GEOLOGY

The dominant rock types in the area are Jurassic sandstones and marls of the Weald facies (Calderón, 1910). These marls, containing more than 50% clay and at least 15% calcium carbonate, are the typical host rock of the pyrite crystals. The origin of the pyrite has not been extensively studied, but seems to be related to the decomposition of organic materials in the marl in a reducing environment, releasing sulfur which combines with iron.

In some places the marl has been recrystallized, forming calcite veins and small geodes; associated pyrite crystals tend to be fractured, with crystalline calcite filling the cracks. Fortunately this phenomenon is uncommon, but it affects at least a few specimens at virtually all locations. At Navajún specimens have been found in which calcite-lined geodes occur inside fractured pyrite crystals.

MINERALOGY

Pyrite is the only sulfide found at these locations. At Navajún small pinpoints of a gray material have been seen which may be galena, but these remain unidentified. The host rock contains occasional, small chlorite-filled pockets, particularly at Navajún, Valdeperillo and Villarijo. With the exception of a particular type of pyrite from Ambasaguas, all pyrite found in the area has proven to be stable under all conditions of storage.

In many cases the pyrite occurrences crop out and have thus been exposed to surface oxidation, resulting in some nice pseudomorphs of limonite after pyrite. Other alteration products include small crusts

Figure 1. **The Arroyo de las Cañadillas locality near Ambasaguas.**

and crystals of gypsum; earthy yellow cauliflower-like masses of jarosite to several centimeters; and other admixed iron sulfates, which grow particularly well in cavities protected from rainwater.

LOCALITIES

Navajún, La Rioja

The principal producing occurrence is a prospect located in the headwaters of the Barranco de la Nava, about 2.5 km north-northwest from the town of Navajún; it is accessible only by four-wheel-drive field vehicles. The prospect, currently under claim, is mined for specimens only. It consists of a small open pit and an adit. Collecting by outsiders is forbidden.

Work first began here in the early 1970's, and the resulting specimens have become world famous. They were first reported in the *Mineralogical Record* by Wilson in 1976. Since then, literally tons of crystals have been collected and sold, including many fine museum-quality pieces. The principal exporter of specimens to America has been J. Chaver, Madrid.

The pyrite habit is almost exclusively cubic; only very rarely are small octahedron faces observed on the corners. Crystals reach a maximum of 20 cm (Callem, 1981), but are usually 5 cm or less. Many large cubes are actually near-parallel groups of smaller cubes, although it can be difficult to make a distinction. Single crystals and groups of up to 20 individuals are common in the hard, gray marl.

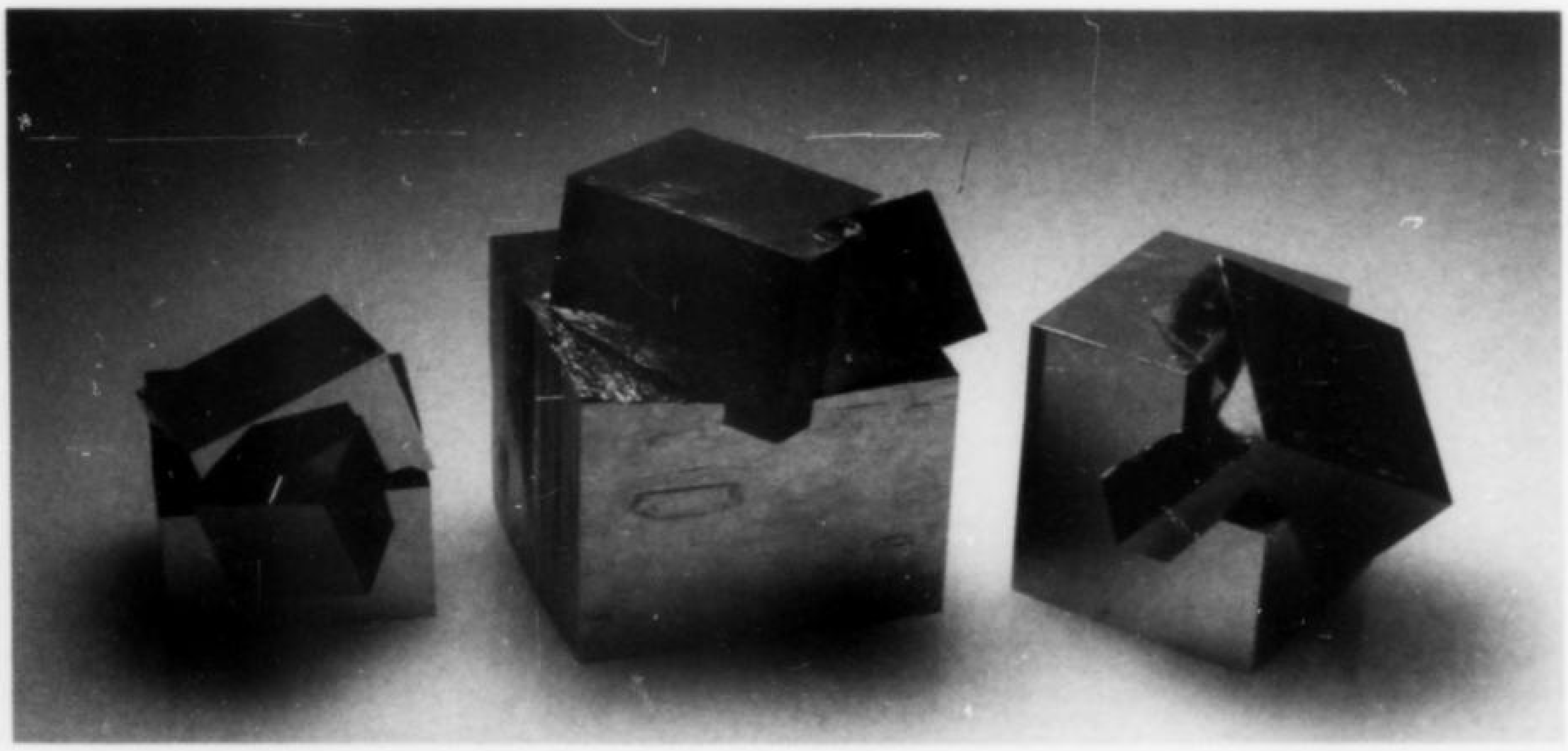


Figure 2. **Pyrite crystals to 5.3 cm from Navajún. J. Chaver specimens, now in the collection of Donald Wyman.** WEW

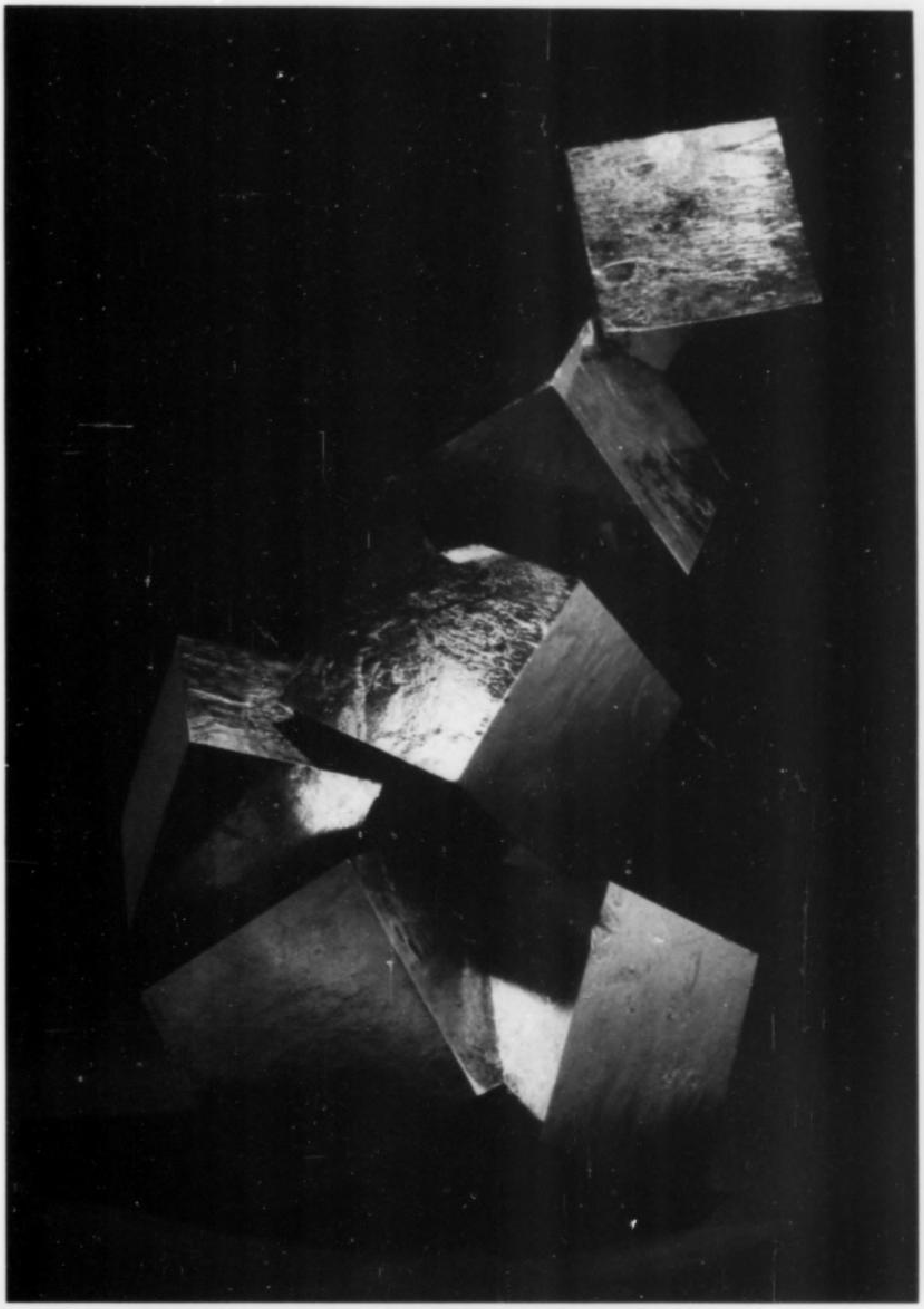
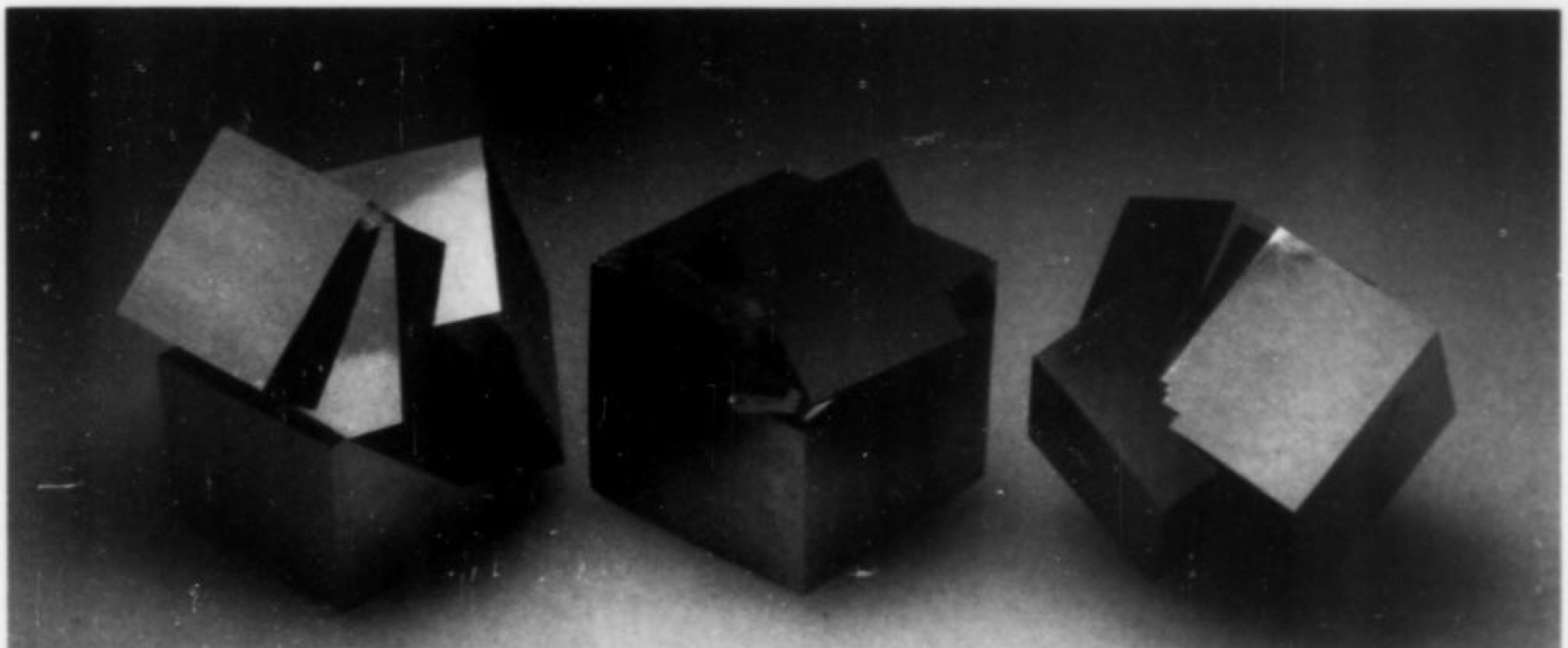


Figure 3. **Pyrite crystal cluster from Navajún. The group is 20 cm tall. Smithsonian specimen; photo by Dane Penland.**

Figure 4. **Pyrite crystals to 4 cm from Navajún. J. Chaver specimens, now in the collection of Donald Wyman.**



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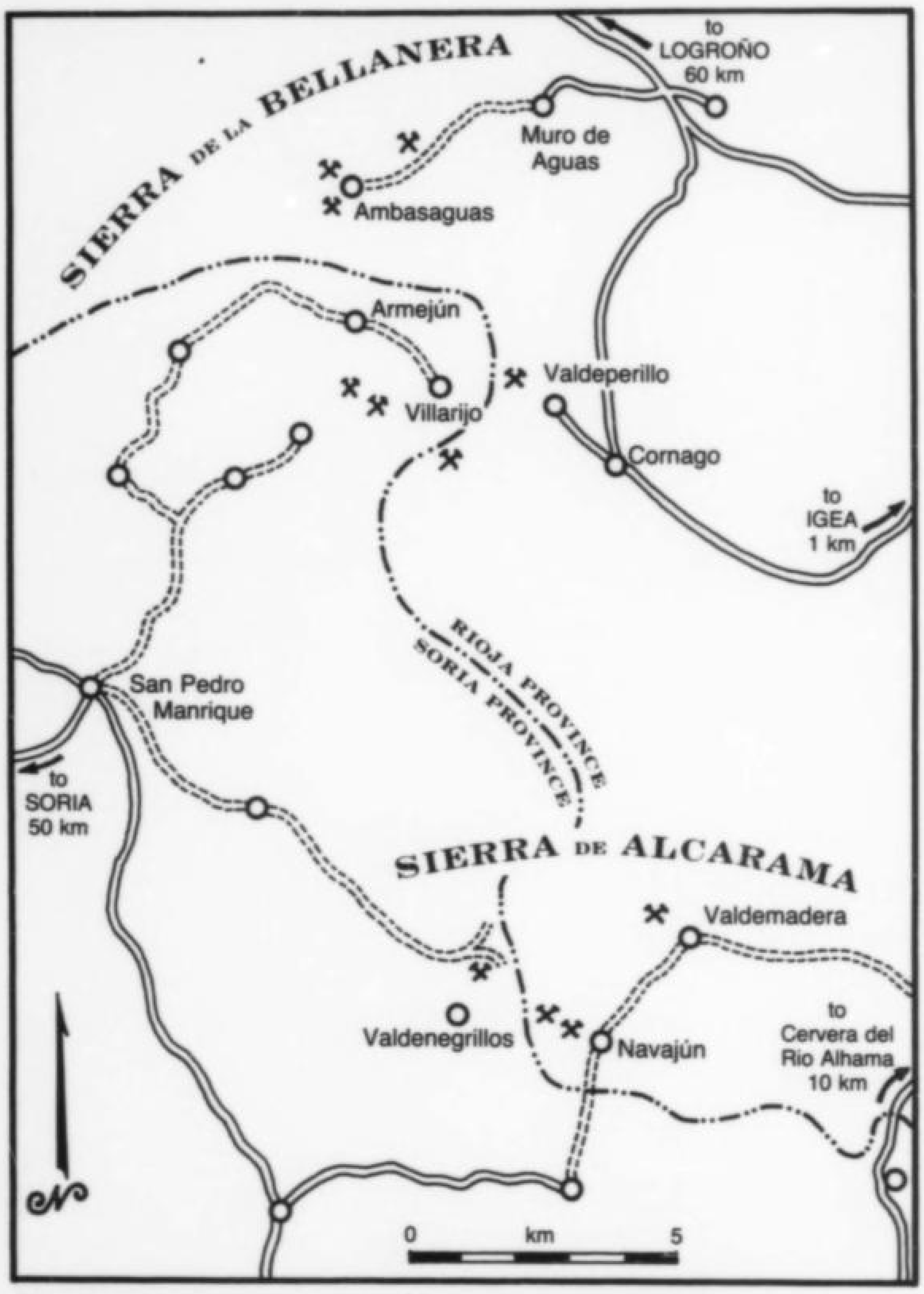


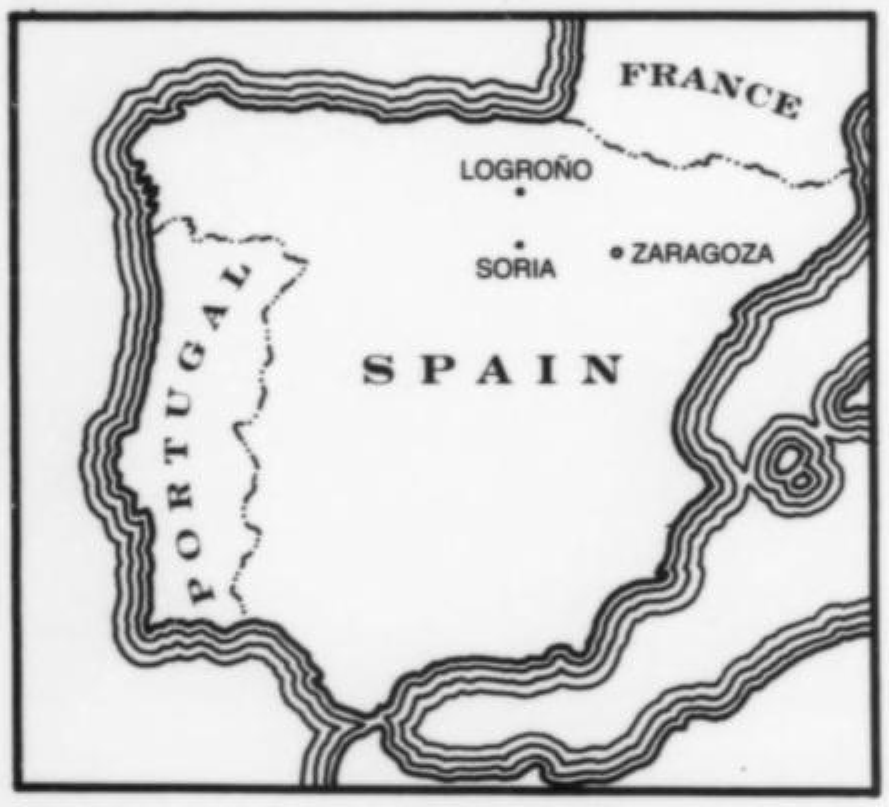


***Figure 5.* Location map.**

Crystal faces are usually mirror-smooth but may also be striated by oscillation with tiny pyritohedron faces on small crystals.

Navajún specimens are sometimes mislabeled as "Ambasaguas."

Between the town and the main prospect, near the road, is another occurrence held under the same claim. Pyrite clusters to 4 cm consisting of many perfect cubes in gray marl are found there.

Ambasaguas, La Rioja

Three major pyrite occurrences exist around the town of Ambasaguas. First is the Arroyo de las Cañadillas, located between Muro de Aguas and Ambasaguas. Pyrite of two habits is found here in a gray-black marl: simple pyritohedrons 2–20 mm, and intergrown clusters 2–10 cm across composed of distorted and striated pyritohedrons. The interiors of the clusters have a radially fibrous structure. All specimens are bright brass-yellow, except those found near the surface, which have been weathered. The large clusters, those exceeding 5 cm or so, have unstable cores which will expand and crack if stored under humid conditions. Iron sulfates are abundantly associated with the clusters.

The Arroyo de la Urruñada is the classic occurrence for "Ambasaguas" pyrite. It is located about 500 meters west-southwest of town, where four small adits (now partially collapsed and dangerous) were once worked for pyrite specimens. The crystals from here, found as individuals and groups in white marl, are predominantly cubic with pyritohedron modifications and heavily striated cube faces. Crystals reach a maximum of 3 cm, usually closer to 1–1.5 cm, and in many cases have a light film of iron oxides which is easily removed with oxalic acid, leaving a bright luster. The third occurrence near Ambasaguas is the Arroyo Vallaroso, located about 500 meters west-northwest of town. It is currently the most heavily collected prospect in the area, yielding bright yellow, well formed pyritohedrons and cube-pyritohedrons in gray marl. Crystals occur isolated or in groups, sometimes very distorted, in sizes up to about 3 cm. Crystals are abundant, and showy hand-sized specimens consisting of many bright crystals in matrix are obtainable.

Ambasaguas is today a ghost town. Administratively the area comes under the jurisdiction of nearby Muro de Aguas, a name which may also appear on labels for pyrite from this occurrence.

Valdeperillo, La Rioja

The main digging area near Valdeperillo is situated in the Barranco de Solañán, 3 km upstream from the town in a west-northwesterly direction. It is accessible only by footpath, and is currently under claim. The prospect is worked for specimens on a small scale during the summer months. The major point of interest for pyrite crystals from this locality is the very distorted, unequal development of cube faces which results in prismatic to tabular habits having edge ratios of up to 7:1, and maximum dimensions of about 5 cm. The elongated crystals have no preferred orientation in the host rock.

Unfortunately, most of the pyrite crystals from this location have internal fractures which make them very difficult to remove undamaged from the hard marl. In some cases the crystals are cut by chlorite pockets.

About 500 meters farther upstream is a small prospect which yields striated cubic crystals to 2 cm. Crystals emplaced near the surface have generally been corroded into a spongy mass of remnant pyrite retaining only a crude cubic shape.

A less interesting location near Valdeperillo is the Molino del Campillo, by the Linares River roughly 2 km northwest of town. Here loose single crystals to 3 cm, coated with compact limonite, can be found on the surface.

Valdenegrillos, Soria

About 500 meters north-northeast of Valdenegrillos is the collecting area known as Corrales de la Solanilla. This was once considered a "classic" locality before the Navajún occurrence was discovered just a short distance away. The site is reached by a forest road; a 30-meter adit and an abandoned well for livestock mark the prospect.

Pyrite occurs here in hard sandstone, usually as extended groups of attached crystals. Consequently, completely euhedral crystals are impossible to recover. Some sort of attachment or connection point always shows. Furthermore, the pyrite is altered to limonite on the surface. This coating can be removed with acid, but the crystals are dull and lusterless underneath.

Villarijo, Soria

Villarijo is another occurrence mentioned in old writings (Calderón, 1910). Cubic crystals to 10 cm in size were reported, but a size of 4 cm or less is most common. The workings are located in Arroyo de Valoria, near a sandy road about 2 km west of town. Pyrite crystals are exposed in the bed of the stream.

Crystal habit is cubic with small octahedral modifications, but usually deformed, with crude faces meeting at abnormal angles. The

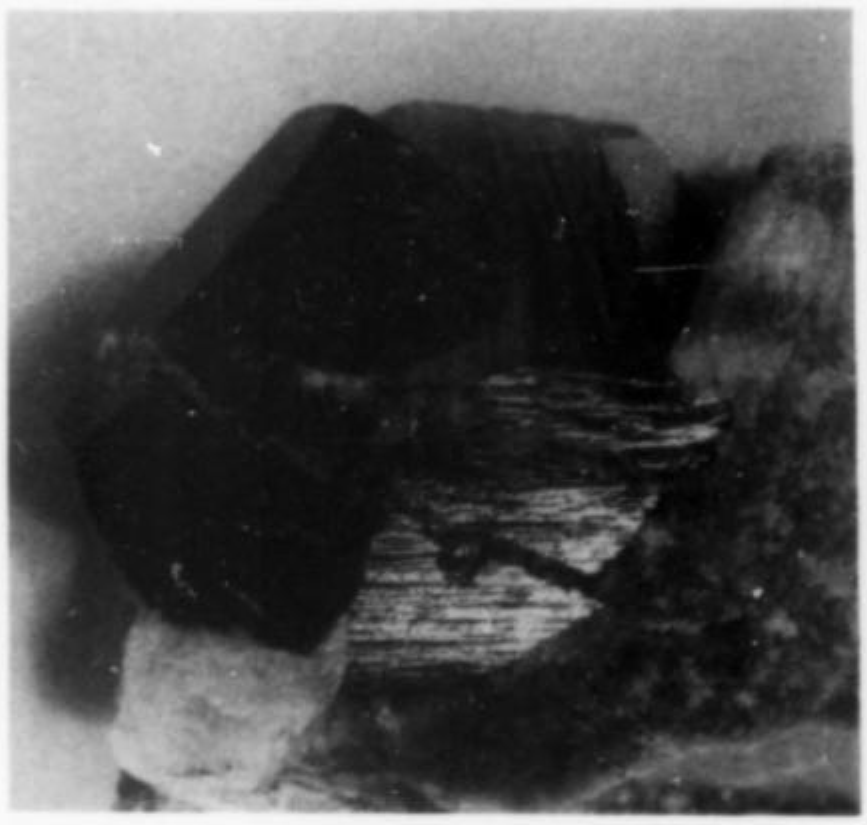
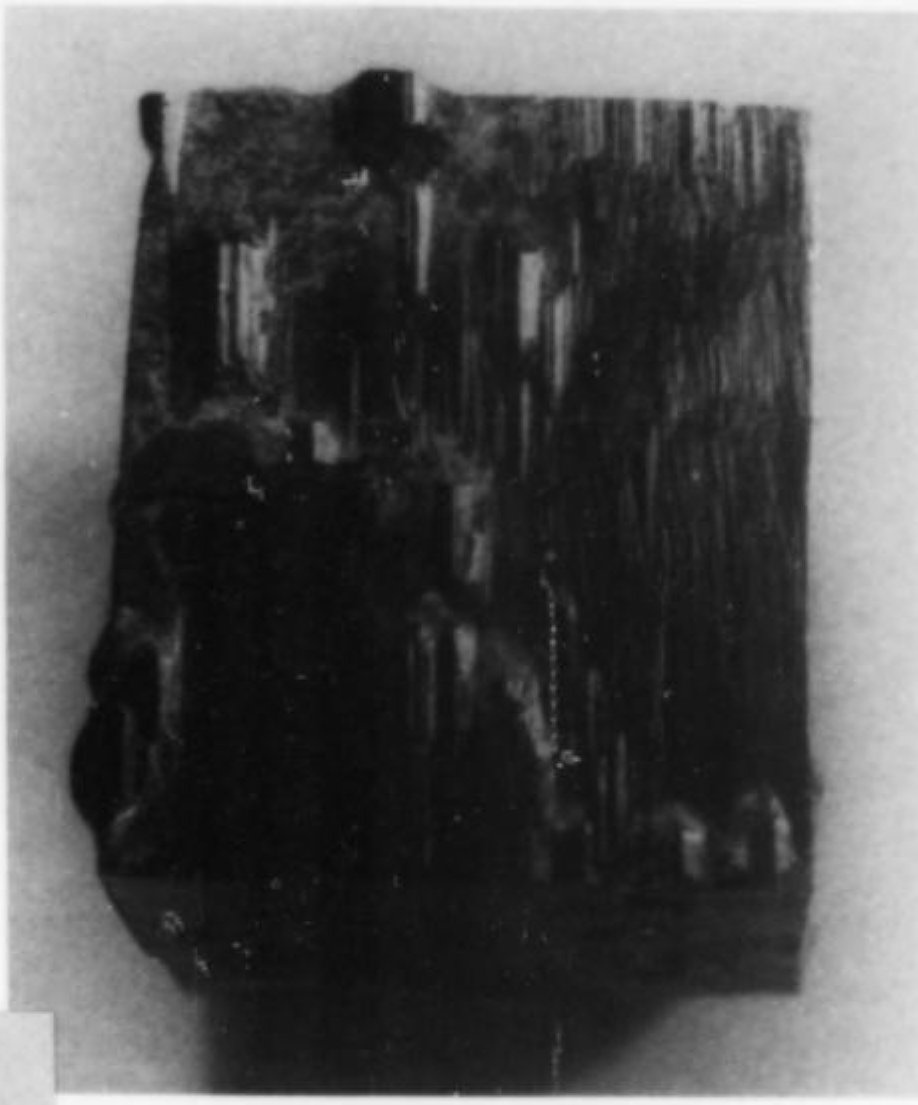


Figure 6. Calcite-filled fractures in pyrite crystals, 2 cm, from Arroyo de Vallaroso near Ambasaguas.



(Except as noted, all specimens are from the collection of, and photographed by, M. Calvo.)

Figure 7. Pyrite crystal showing "wrinkles" caused by incipient pyritohedron faces; 1.8 cm, from Barranco de la Nava, near Navajún.

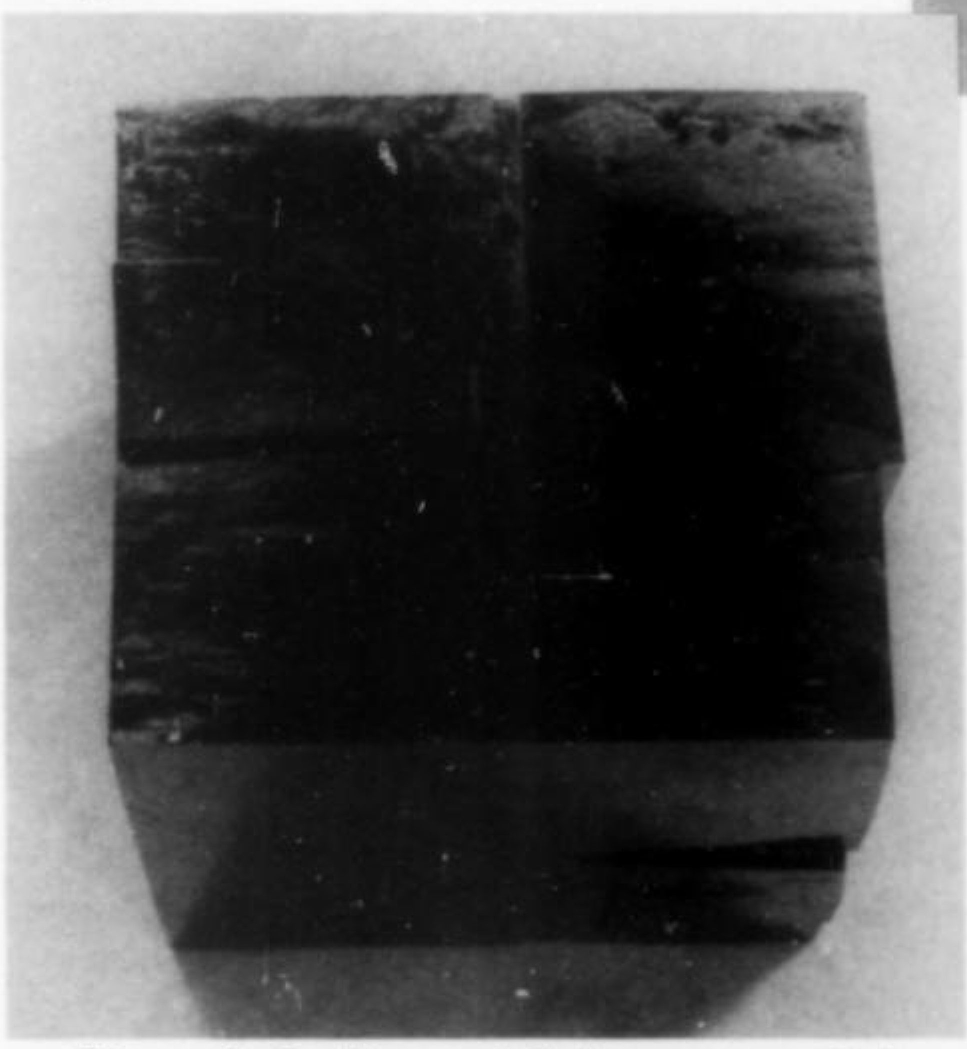


Figure 8. Pyrite crystals in near-parallel growth, 4.5 cm on edge, from Barranco de la Nava, near Navajún.

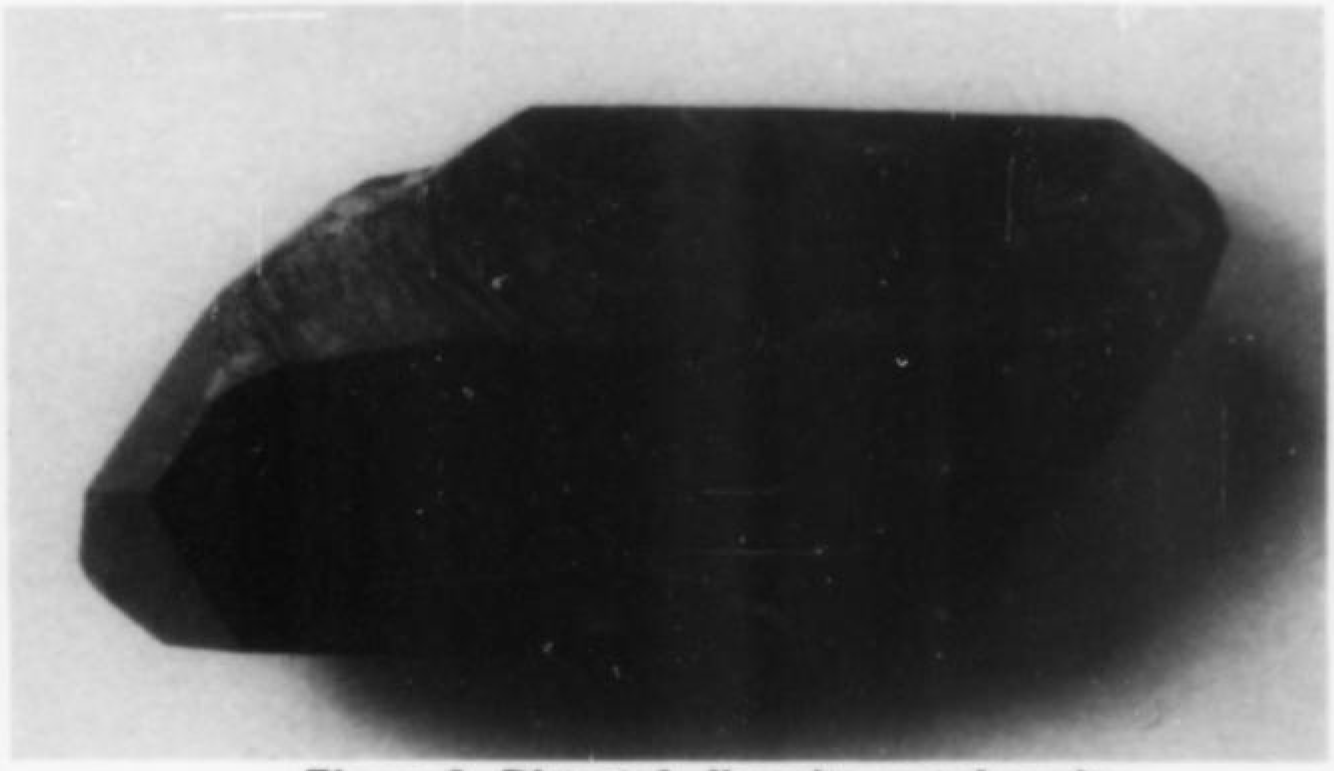


Figure 9. Distorted, limonite-coated pyrite crystal, 2 cm, from Cabretón.

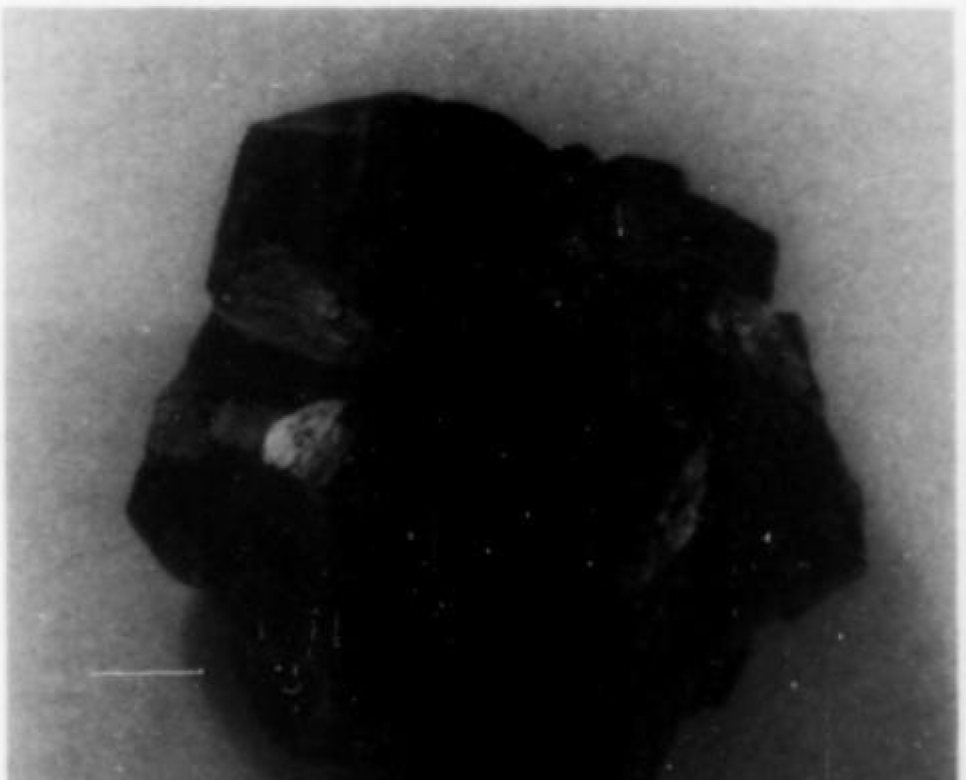


Figure 10. Pyrite crystal cluster, 3.5 cm, from Arroyo de las Cañadillas, near Ambasaguas.

Figure 11. Elongated pyrite crystals to 4.2 cm in marl from Barranco de Solañán near Valdeperillo. The dark specks are chlorite.

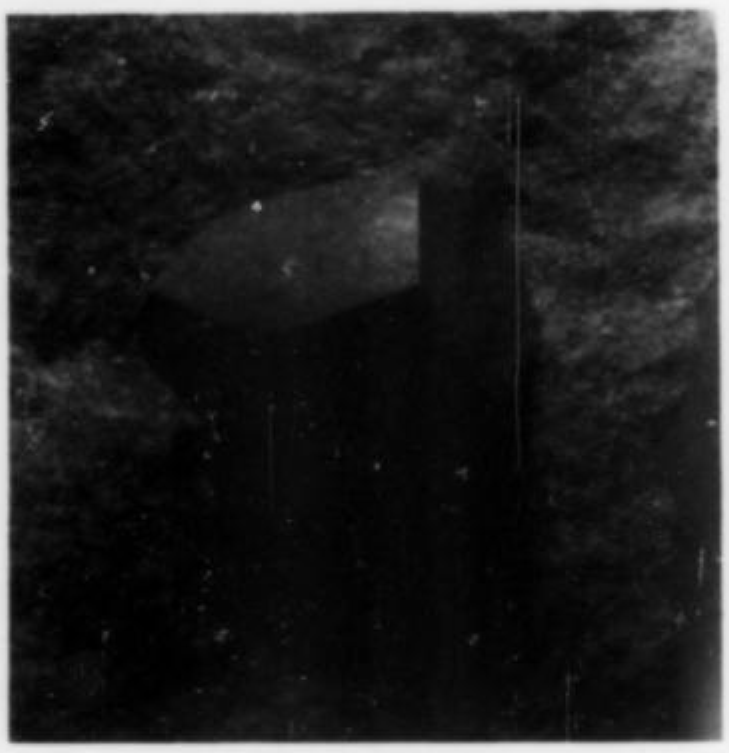


Figure 12. **Pyrite pyritohedron, 2.7 cm, in gray marl from Arroyo de las Cañadillas, near Ambasaguas.**

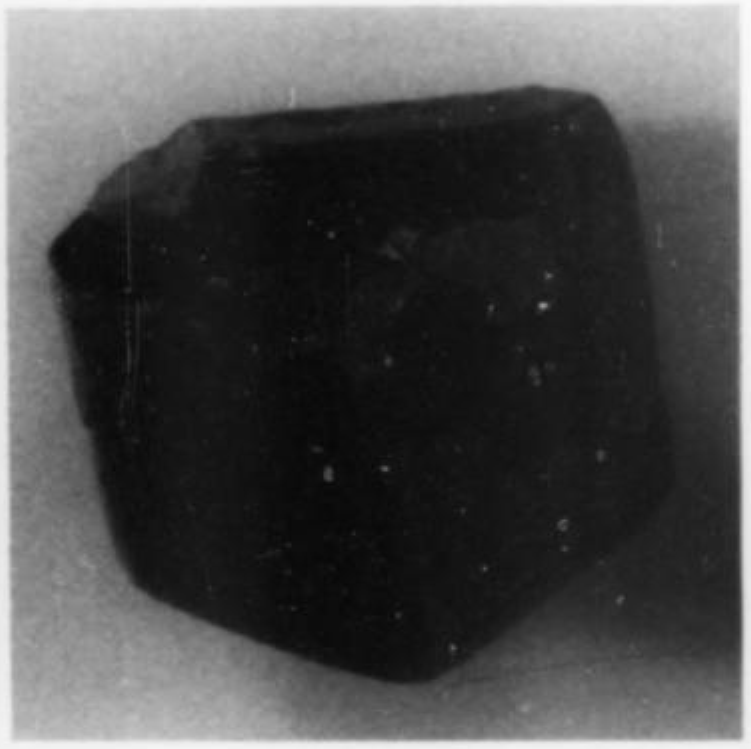


Figure 13. **Heavily striated cube-pyritohedron crystals, 1.5 cm, from Arroyo de la Urruñada, near Ambasaguas.**

Figure 14. **Restored corner on a pyrite crystal from Navajún. Note the difference in luster. Arte collection.**

matrix of white marl shows pressure shadows around the imbedded crystals, and exhibits some degree of schistosity.

Above the ravine, pyrite cubes to 3 cm and smaller pyritohedrons and cuboctahedrons have been found with a hard, bright limonite coating. This occurrence is actually closer to Armejún. Villarijo, Valdenegrillos and Armejún are all ghost towns under the administrative jurisdiction of the town of San Pedro Manrique.

Other Locations

Pyrite occurrences are widespread over the entire area between Navajún and Ambasaguas. Some other localities that have produced interesting specimens include Igea (crystals to 8 mm having unusual crystal forms reported by Candel, 1924), Cabretón (crystals to 2 cm in complex, unequal developments which are difficult to orient), and

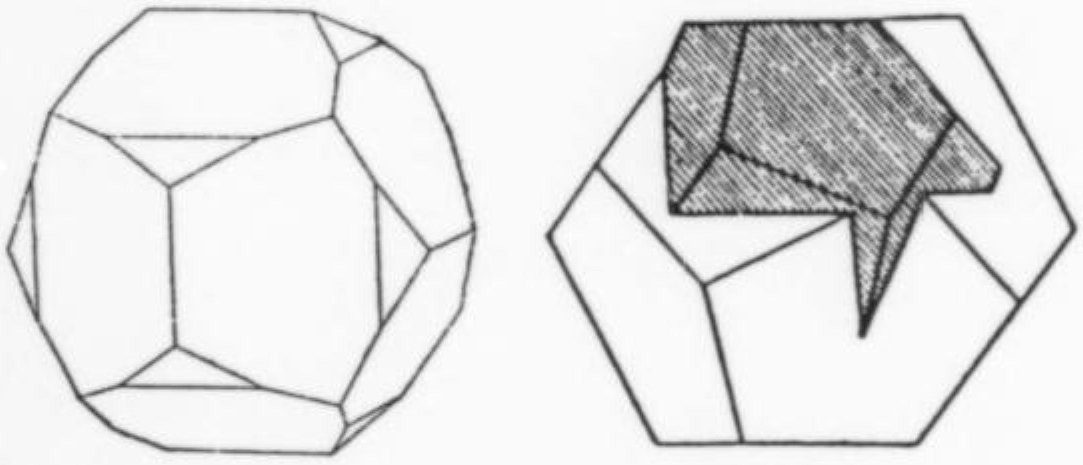


Figure 15. **Crystal drawings of pyrite from Igea, including a penetration twin (Candel, 1924).**

Valdemadera (cubes to 6 cm, partially or totally altered to limonite). Other occurrences of small, usually oxidized crystals have been found in the surrounding area. In Soria province additional occurrences at Agreda, Olvega and Dévanos have been found, as well as at San Martín del Moncayo in Zaragoza province (Calvo *et al.*, 1988).

COLLECTING STATUS

The Navajún and Valdeperillo localities, as mentioned, are currently under claim and collecting there is forbidden. All other occurrences are on public land and are open to collecting with hand tools (no heavy equipment). The area is heavily frequented by local and foreign mineral collectors during the summer months. But nearly all specimens reaching the international market are from the commercial operation at Navajún.

RECONSTRUCTIONS and RESTORATIONS

Unfortunately, most of the spectacular crystal groups from Navajún have a very thin layer of marl separating each crystal from the next. Though only a few tenths of a millimeter thick, this layer causes the groups to separate quite easily during removal from the hard matrix. The groups are usually reassembled with glue at the site, making acceptable reconstruction provided that potential buyers are properly advised.

The process is taken a step further where small fragments are missing. These are sometimes filled in with a brassy metallic paste that is commercially available; such pieces are more properly termed *restorations* as well as reconstructions. Inexperienced collectors may not notice the filled areas; but the luster and color are obviously different, and more observant collectors are not fooled.

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On Right Angle Bends in Filiform Pyrite

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Thirty-five occurrences of filiform pyrite with right-angle bends are documented and a mechanism is suggested to explain their origin.

INTRODUCTION

Pyrite, the most common sulfide mineral, crystallizes in the pyritohedral class (2/m 3) of the isometric crystal system. Pyrite crystals are normally equant and bounded by cubic, octahedral and/or pyritohedral faces (Gait, 1978). However acicular, filiform or whisker-like crystals are found in many low-temperature hydrothermal deposits. The crystals are typically small, a few millimeters or less in length, with length-to-width ratios of 100 or more. These symmetrically distorted cubes may exhibit one or more sharp, right-angle bends.

LOCALITIES

Thirty-five worldwide occurrences of acicular pyrite showing right-angle bends are listed in Table 1 according to the rock type in which they occur. The most frequent occurrence by far is in basalt and diabase, where the pyrite is associated with such late-formed minerals as quartz, calcite and a variety of zeolites. The pyrite is found in crystal-lined vesicles and vugs or, less commonly, in veins. Similarly, filiform pyrite found in fissures and veins cutting gneiss is among the last minerals to form. Associates are quartz, calcite, fluorite, sulfides and stilbite. In limestones, dolomites and shales, filiform pyrite is usually found in the open spaces of geodes and concretions associated with quartz, barite, carbonates and other sulfides. Since the pyrite in all these occurrences is found on, in and supporting the associated minerals, it must be contemporaneous with them and of low-temperature origin. Furthermore, because vesicles, vugs, geodes and concretions are far from being open systems, it appears that most or all of these acicular pyrites crystallized from fluids that were restricted in their circulation.

DESCRIPTION

Despite the restriction that the pyrite crystals discussed here be filiform and exhibit bends, there remains considerable variation in habit, as illustrated in the accompanying photographs (Figs. 1–14). Crystals of moderate "aspect" (length-to-width) ratio that exhibit a single right-angle bend (Fig. 1) are most common. Crystals with multiple bends such as that from Maxwell Point State Park, Oregon (Fig. 2), are considerably less common. More aesthetically pleasing are extremely thin needles such as those shown in Figures 3–5. Those from Rock Island Dam, and the Clackamas River specimen in Figure 4 have aspect ratios as high as 100, while the extremely slender, unbent crystal in the extreme lower left of Figure 5 has an aspect ratio of greater than 250.

In rare cases a crystal may be bent twice at 45° rather than once at 90° (Figs. 6 and 7). In these cases, the portion between the two 45° bends is often thicker, and has irregular rather than smooth sides. As shown in Figure 6, it is not necessary that the two legs of such a crystal be of the same thickness. In most cases, they are not.

Crystals are sometimes found with two right-angle bends such that the crystal grows back on itself, as does the crystal from Halls Gap shown in Figure 8. Complex crystals from Milan, Ohio (Figs. 9 and 10) are particularly interesting. The former is included within a barite crystal, the top face of which has been polished to allow the pyrite to be photographed. The latter was found as an inclusion in quartz, and was etched free to allow photography using the electron microscope.

Extremely rare at most localities are T-shaped crystals such as that from the Clackamas River shown in Figure 11. More common are cases where filiform pyrite grows from a normal pyrite crystal such as that from Lyttelton Harbor shown in Figure 12, or where a filiform crystal terminates in an equant pyrite, as in Figure 13. This crystal from Sugar Grove, West Virginia, also demonstrates that filiform pyrites are frequently of a flattened, ribbonlike form, rather than of perfectly square cross section.

Almost all filiform pyrites are bounded solely by cube faces, and are, of course, elongated parallel to a cube [100] axis. As mentioned

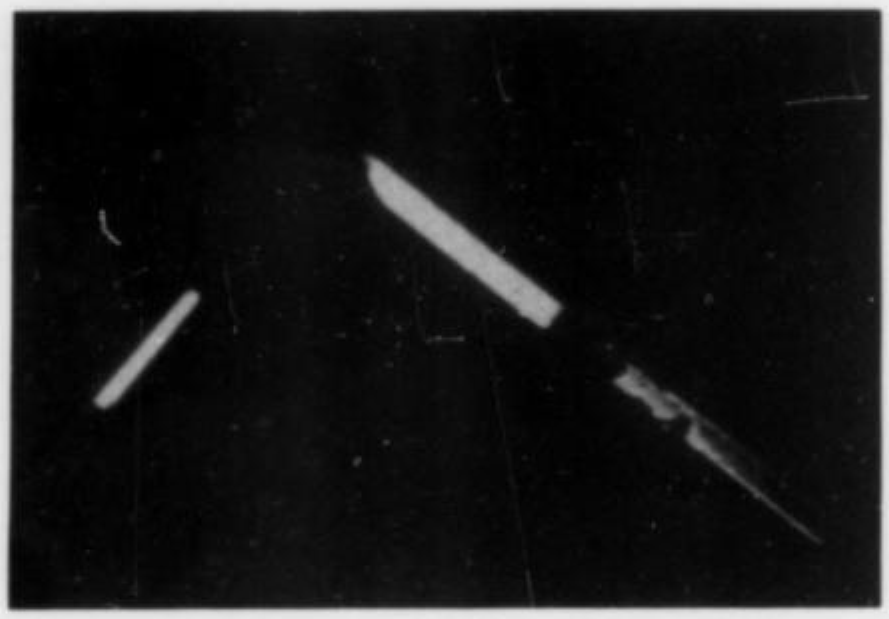

Figure 1. Filiform pyrite from Sugar Grove, West Virginia showing right-angle bend, on and partially covered by a blue, claylike mineral. Length of crystal, 0.5 mm; Erich Grundel specimen.

Figure 2. Whisker pyrite crystal showing multiple right-angle bends, from Maxwell Point State Park, Oregon. The crystal is 0.6 mm high; collected by Violet Frazier.

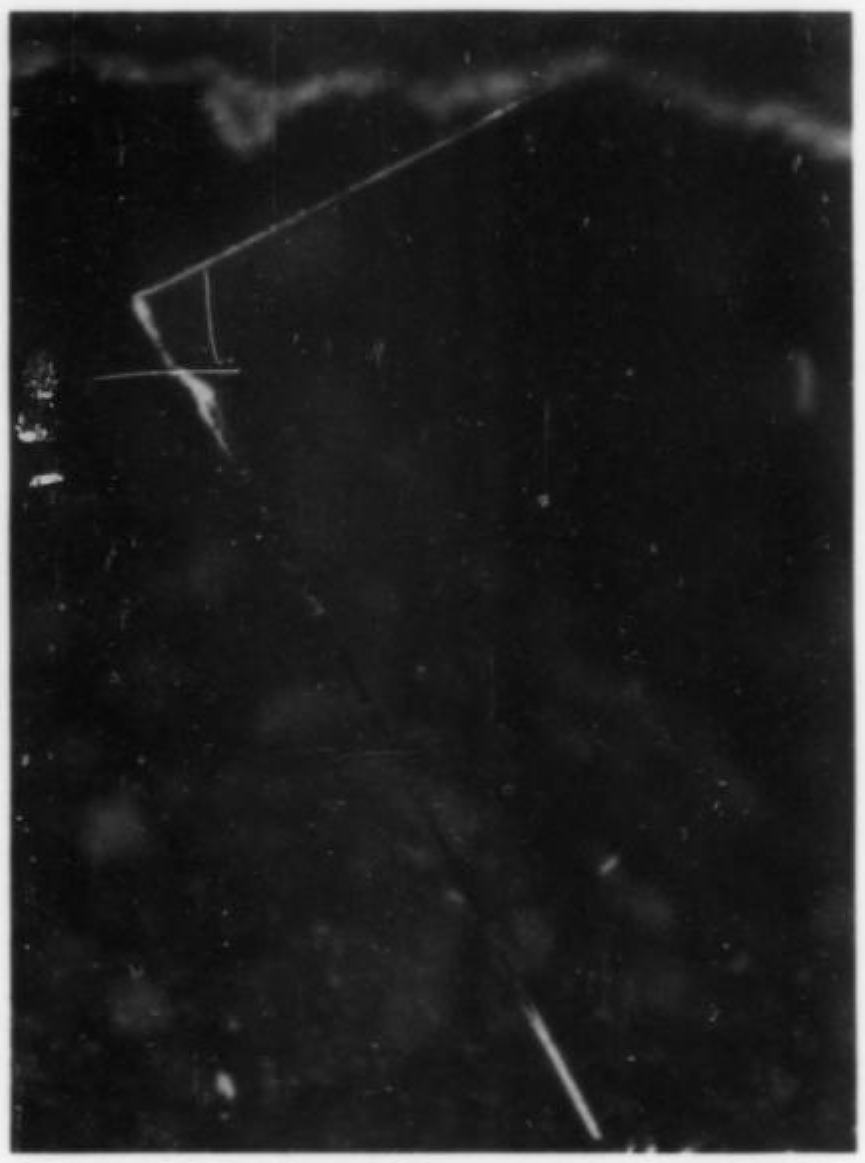

Figure 3. Slender whisker crystal of pyrite, 1.2 mm long, from Rock Island Dam, Columbia River, Washington. Collection of Wm. A. Henderson, Jr.

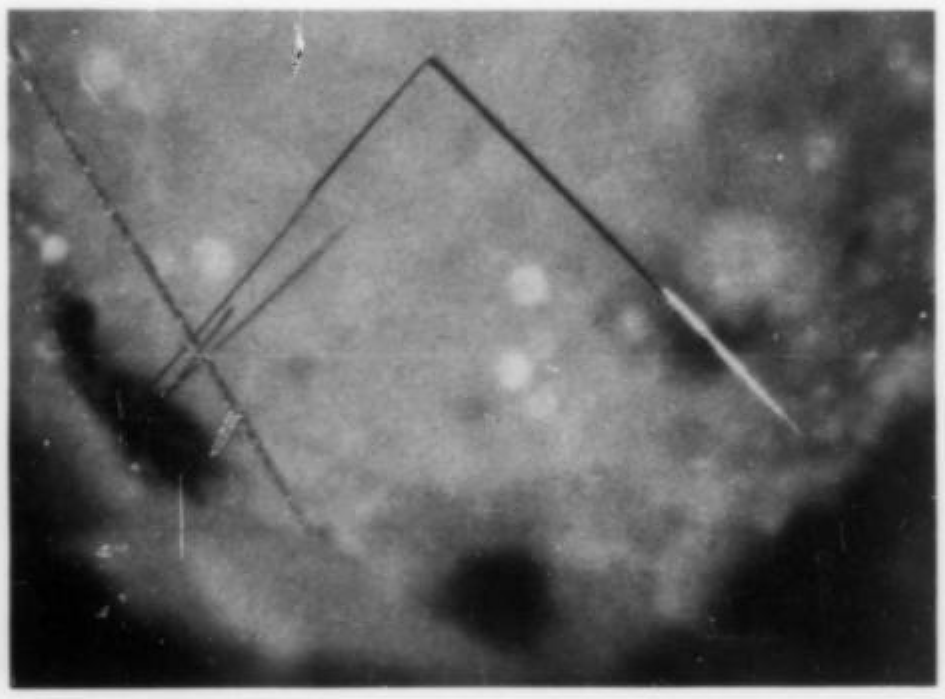

Figure 4. Acicular pyrite with right-angle bend from Clackamas River, Oregon. Field of view 2 mm; Wm. A. Henderson, Jr. specimen.

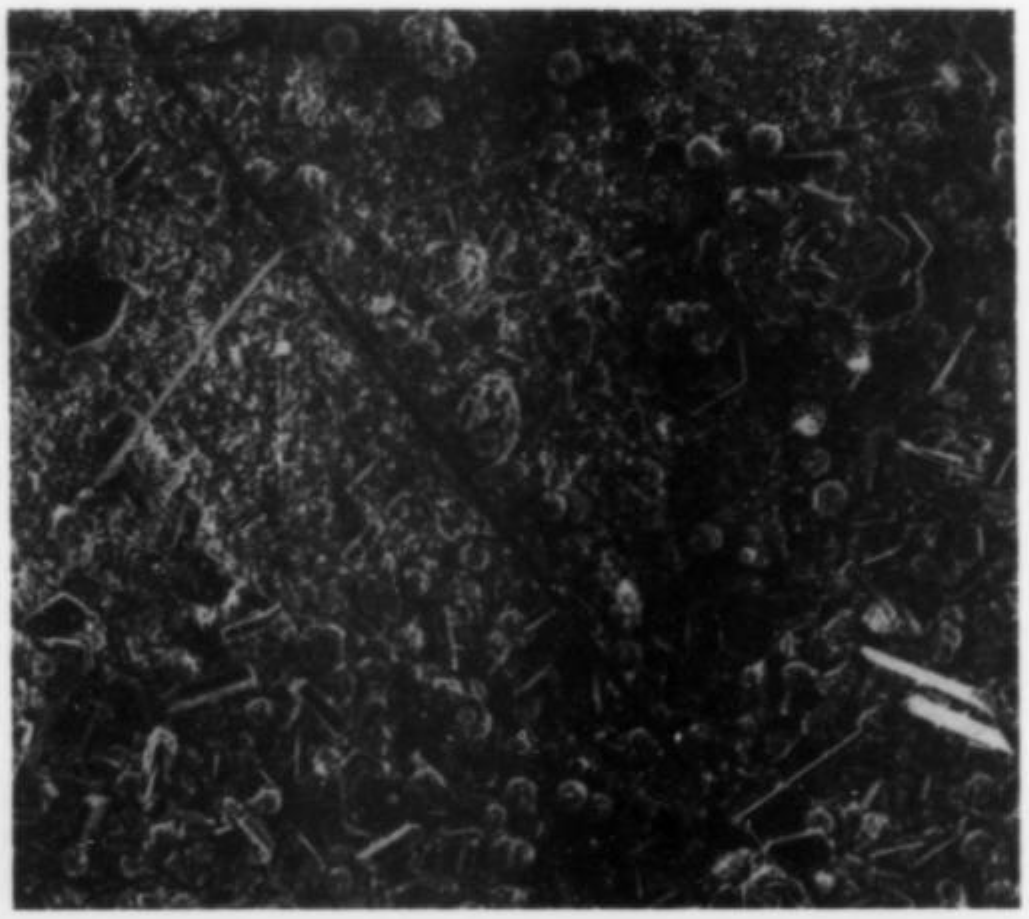

Figure 5. Group of three whisker pyrite crystals, two with right-angle bends, the largest 2.0 mm long. The thinnest one, without a bend, at lower left, is 0.0025 mm wide. From Clackamas River, Oregon; Jean Downing specimen.

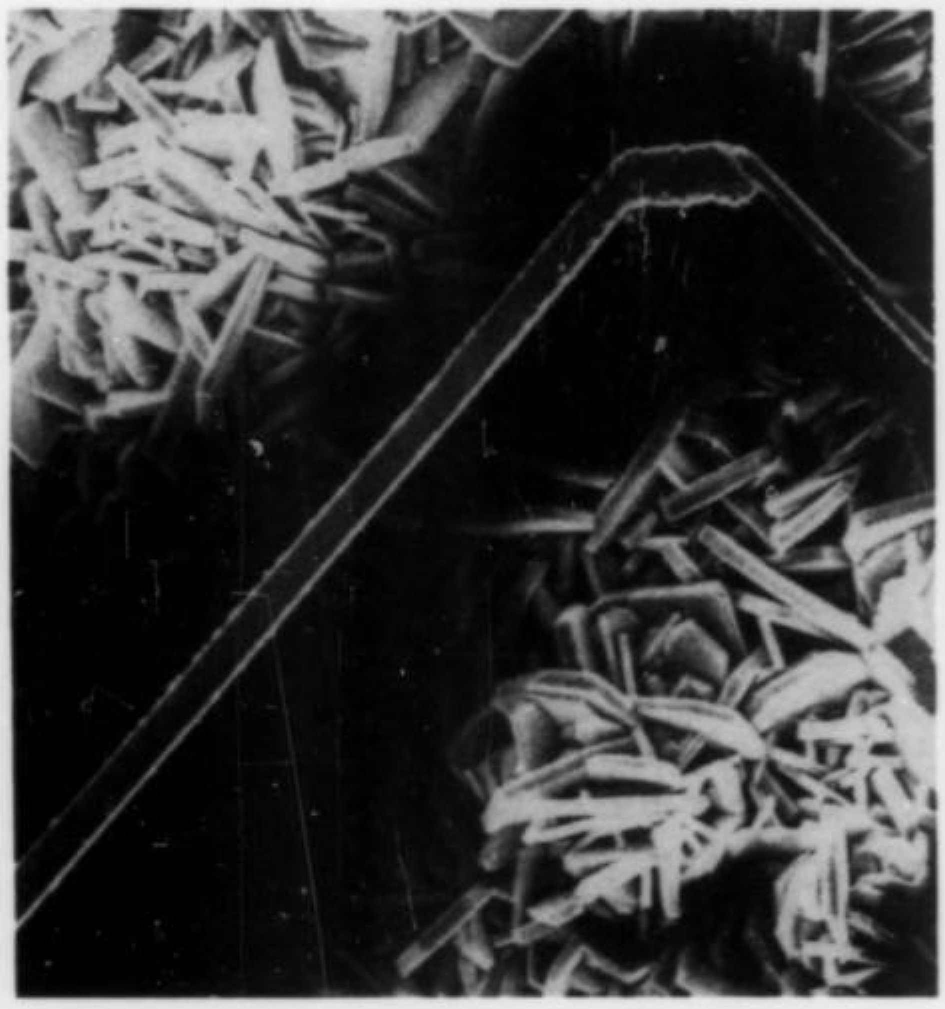

Figure 6. SEM photo showing 45° bends in pyrite from Clackamas River, Oregon. Field of view, 0.6 mm; Violet Frazier specimen.

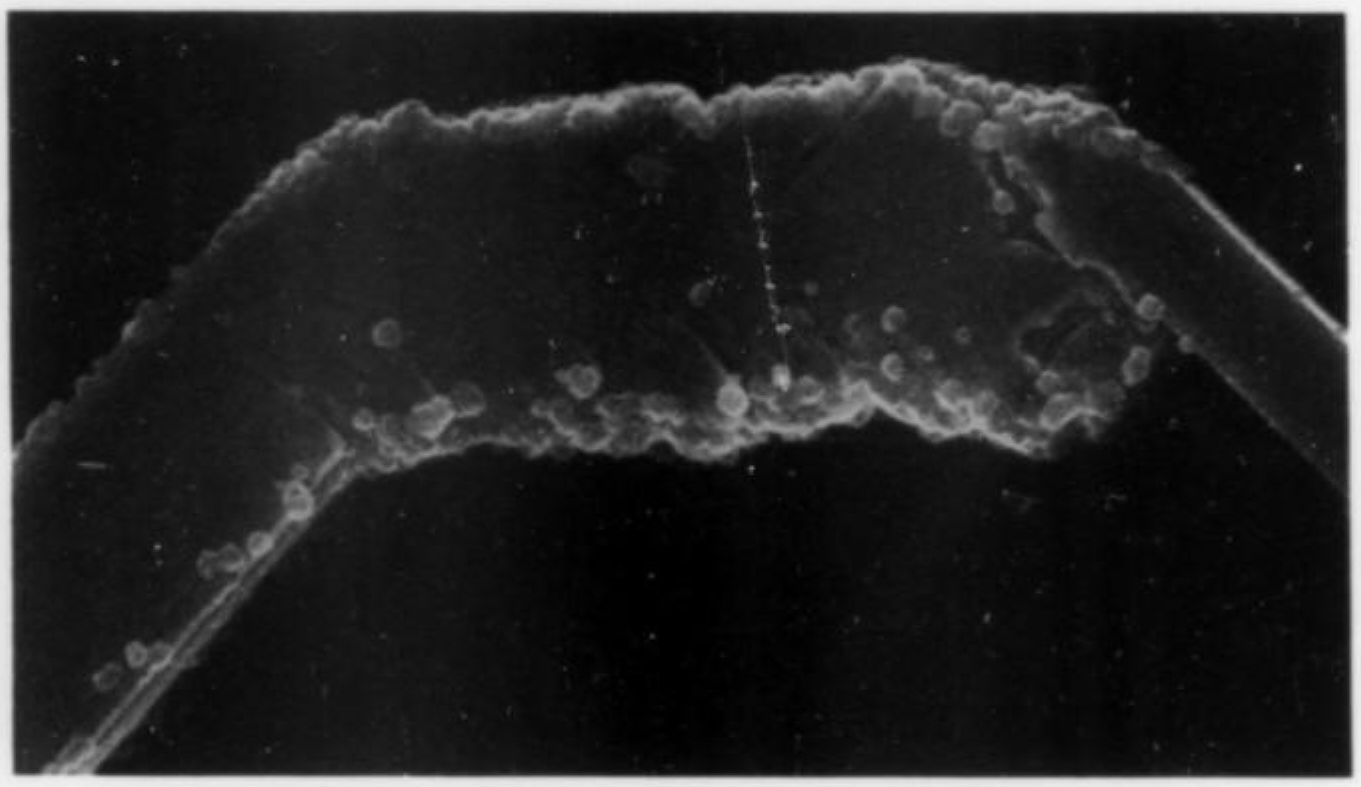

Figure 7. Enlarged view of the 45° bend area of the crystal in Figure 6. Width of crystal 0.03 mm.

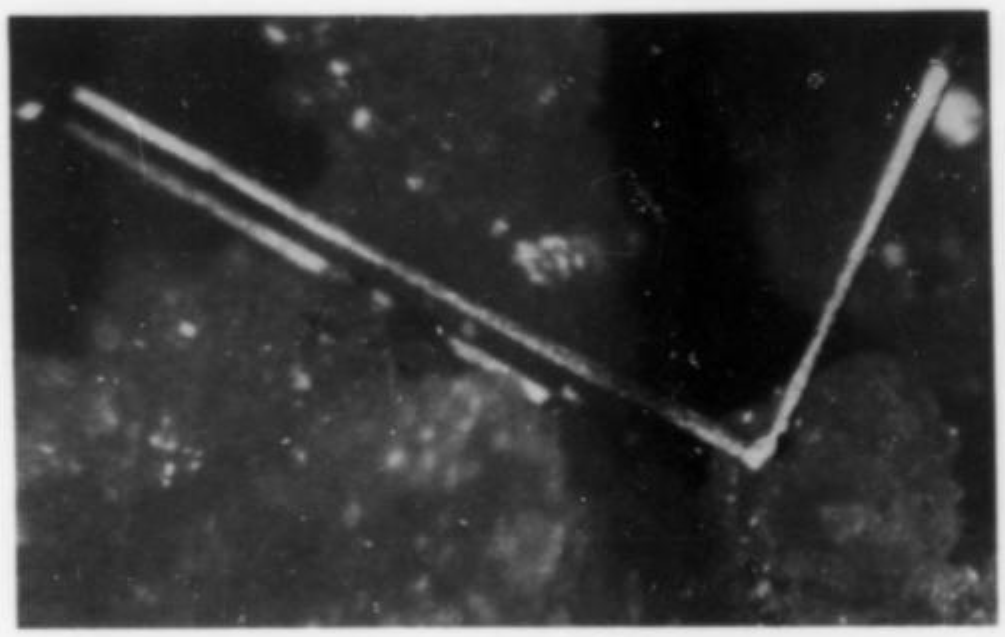

Figure 8. Acicular pyrite from Halls Gap, Kentucky, showing multiple right-angle bends. The long leg of the crystal is 1.3 mm; Omer Dean specimen.

Figure 9. Multiple crystals of acicular pyrite showing right-angle bends within barite, from Huron River, west of Milan, Ohio. Specimen from R. Peter Richards; field of view 1.5 mm.

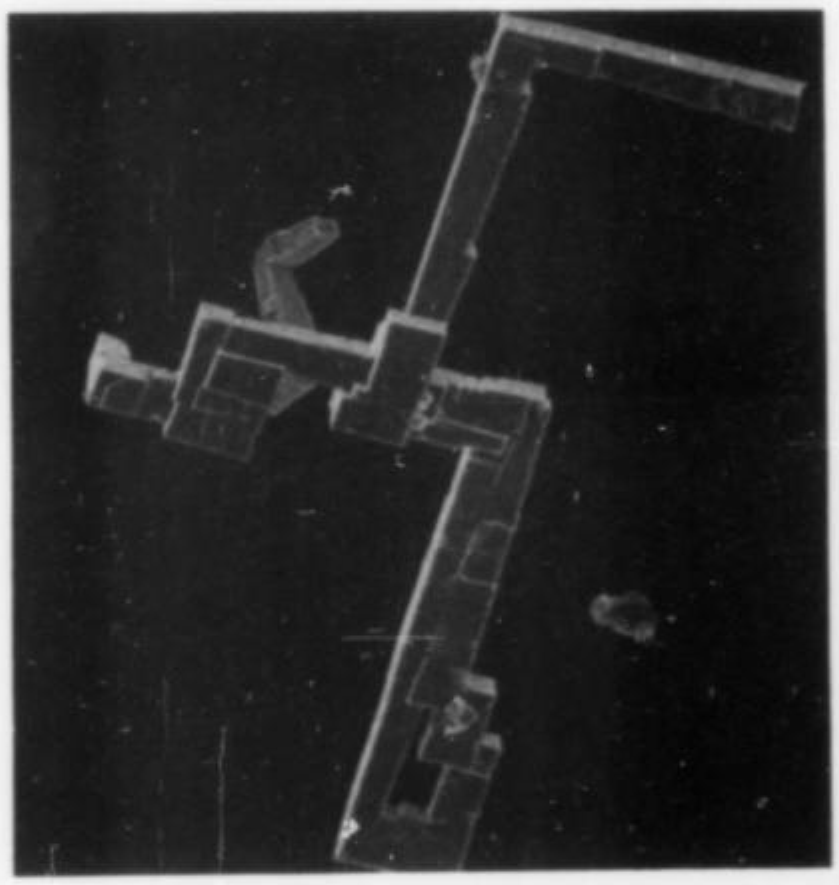

Figure 10. SEM photo of pyrite crystals etched from quartz and showing multiple right-angle bends. R. Peter Richards specimen from Huron River, near Monroeville, Ohio; length of group, 0.3 mm.

Figure 11. T-shaped crystal of filiform pyrite; the cross leg is 0.9 mm long. From the Clackamas River, Oregon; Violet Frazier specimen.

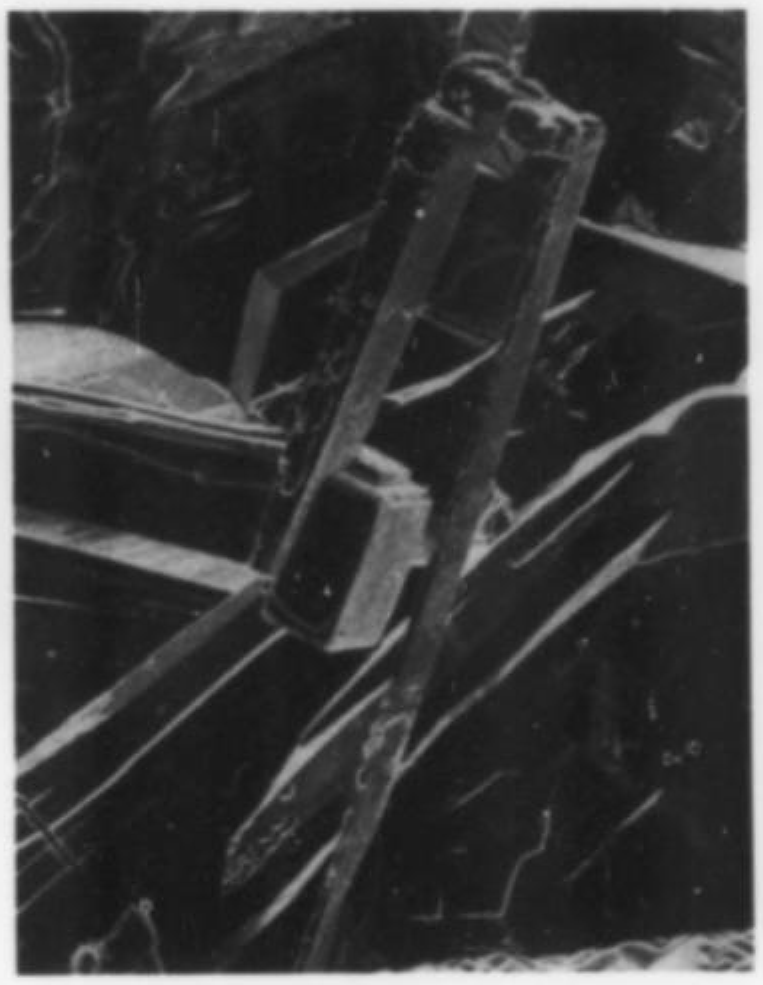

Figure 13. Ribbonlike, filiform pyrite terminating in a cube, from Sugar Grove, West Virginia. Height of crystal, 0.8 mm; Erich Grundel specimen.

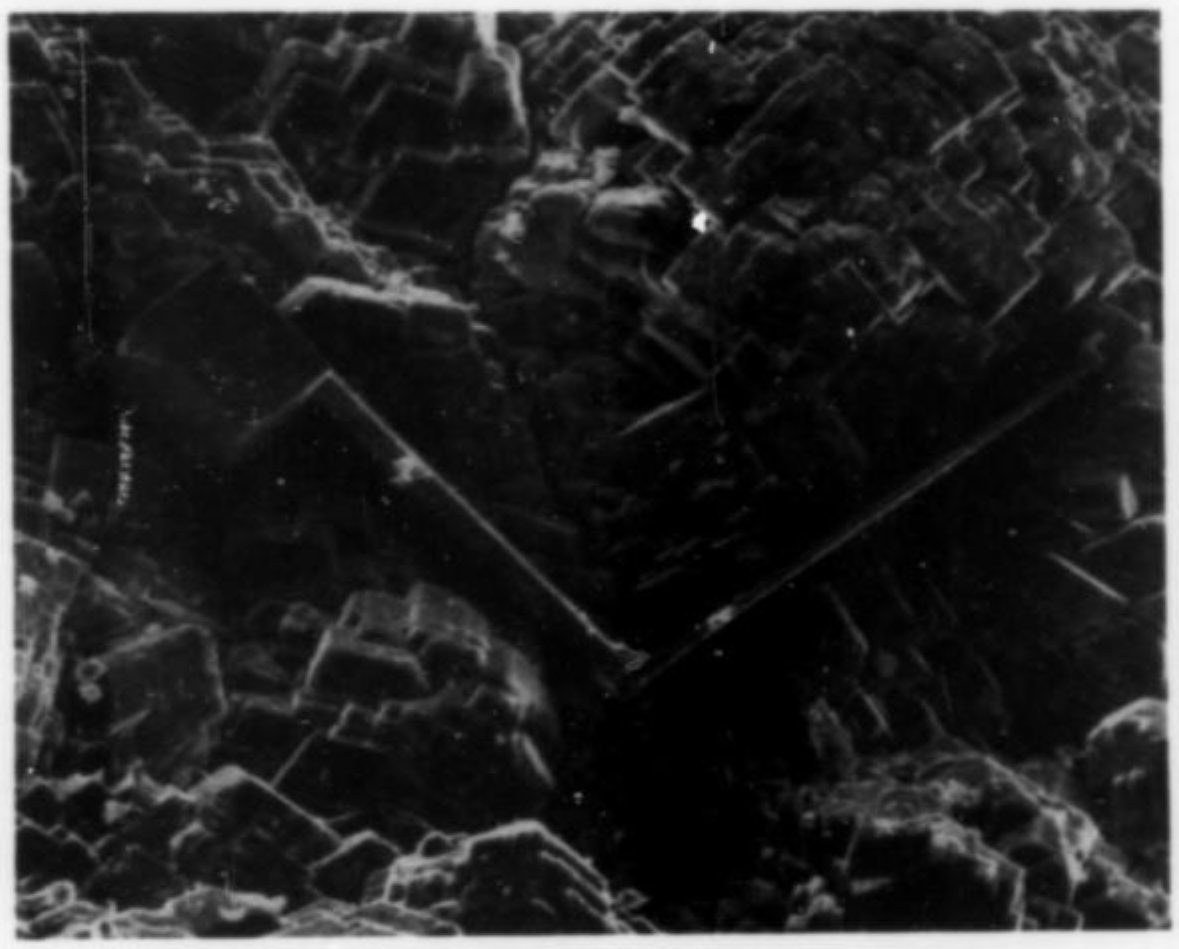

Figure 12. SEM photo of acicular pyrite with right-angle bends growing from a pyrite cube. Lyttelton Harbor Board quarry, Lyttelton, New Zealand. Field of view 0.3 mm; specimen from Ruth Jacobsen.

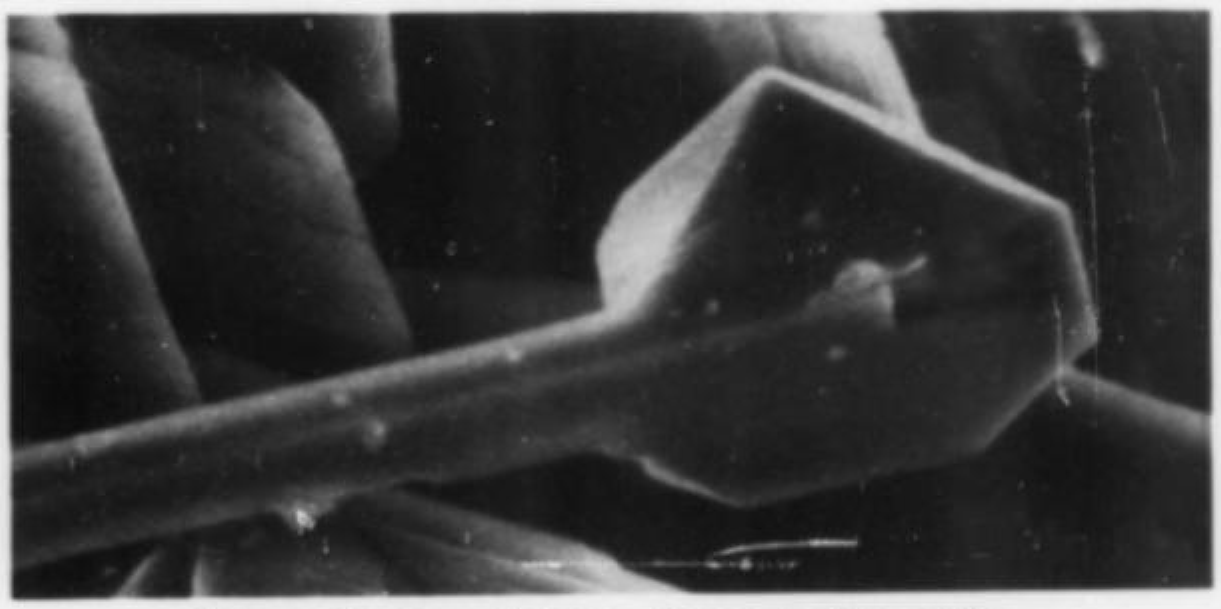

Figure 14. Termination of an acicular pyrite crystal showing cube and possibly octahedron and dodecahedron faces. From Lyttelton Harbor Board quarry, Lyttelton, New Zealand. Field of view 0.1 mm; specimen from Jean Jenks.

above, growth parallel to [110] in the bend region is seen rarely, but of even less common occurrence is a crystal such as that in Figure 14. Here, the termination of a minute filiform pyrite, about 0.05 mm in cross section, is bounded by faces other than the cube, perhaps the octahedron and dodecahedron.

Not shown are curved or smoothly bent crystals of filiform pyrite. These occur at many localities, and such bending can amount to several degrees from one end of the crystal to the other. Crystals of very high aspect ratio are more likely to show such distortion. (See Bideaux, 1970, and Ghiurca and Motiu, 1986, for examples of smoothly curved sulfide crystals and discussions of their possible origin.)

EARLIER OBSERVATIONS

The existence of acicular pyrite is well known, and is mentioned in many of the standard texts. One of the earliest descriptions of acicular pyrite showing right-angle bends is that of examples in limestone from Rondout, Ulster County, New York (Whitlock, 1905). Whitlock described and illustrated crystals with L and T shapes elongated parallel to the [100] axis, and ascribed the right-angle bends to twinning on (011). Shannon (1923) described acicular pyrite from Stillwater, Arkansas, elongated parallel to [100]. He stated that right-angle bends were *not* observed as at Rondout, and mistakenly described the bent Rondout crystals as spinel-law twins, which would be twinned on (111), rather than (011). Kamb and Oke (1950) described and illustrated filiform pyrite showing multiple right-angle bends from Rock Island Dam, Columbia River, Washington. The crystals are small (0.05 x 1–4 mm), and occur in vesicles in basalt. They discovered, by means of X-ray rotation photographs, that the crystals are elongated parallel to the *a* axis (i.e., they are extremely distorted cubes) but made no comments as to whether the crystals were twinned. Still more recently, White (1973) described pyrite with extreme symmetrical distortion (columnar to acicular) from Naica, Mexico. In doing so, he mentioned acicular pyrite from Halls Gap, Kentucky; Haledon, New Jersey; and Clackamas River, Oregon. Although he did not mention bent pyrites from Naica, a photograph of such a crystal from this locality appears elsewhere (Bariand, 1976). Specimens of bent pyrite from Rock Island Dam and Halls Gap are illustrated in the *Encyclopedia of Minerals* by Roberts, Rapp and Weber (1974).

TWINNING AS A POSSIBLE MECHANISM

As proposed by Whitlock, one mechanism for the formation of right-angle bends in pyrite could be twinning by reflection across a dodecahedral (011) plane. This is equivalent to a 90° rotation about the *a* or [100] axis, and is a permissible twin operation in pyrite because this direction has a two-fold rather than a four-fold symmetry axis. Indeed, as shown in Figure 15, this is the twin law observed in "iron cross" twins of pyrite. However, a number of observations have

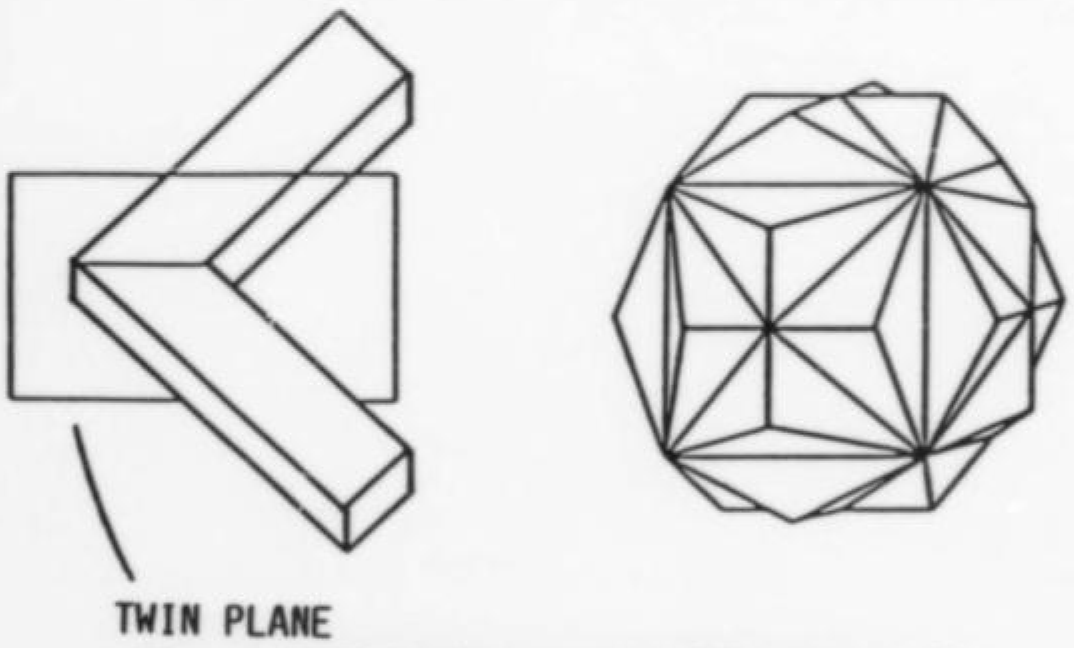

***Figure 15.* Twinning as a possible source of right-angle bends in acicular pyrite: (left) twinning on (110) to give right-angle bend; (right) similar twinning of a pyrite pyritohedron to produce an "iron cross" twin.**

led the authors to conclude that a cause other than twinning must be sought to explain the right-angle bends in filiform pyrite.

Cuprite, CuO, is another cubic mineral noted for its widespread occurrence as filiform crystals. However, cuprite belongs to the hexoctahedral ($\frac{4}{m}\bar{3}\frac{2}{m}$) class of the isometric system and, unlike pyrite, has four-fold symmetry about the *a* axis. Hence, twinning on (011) is precluded. Therefore, *if* bent filiform crystals of cuprite and pyrite form by the same mechanism, and if twinning on (011) cannot occur in cuprite, then twinning on (011) cannot explain the right-angle bends in pyrite.

Equant pyrites of any size more often than not show striations caused by alternation between cube and pyritohedron faces. These striations demonstrate the two-fold symmetry of pyrite about the [100] axis. If right-angle-bend pyrites were formed by twinning, the striations would change direction across the twin boundary (Fig. 16, left), and the crystal would have four-fold symmetry at that point. Alternatively, if

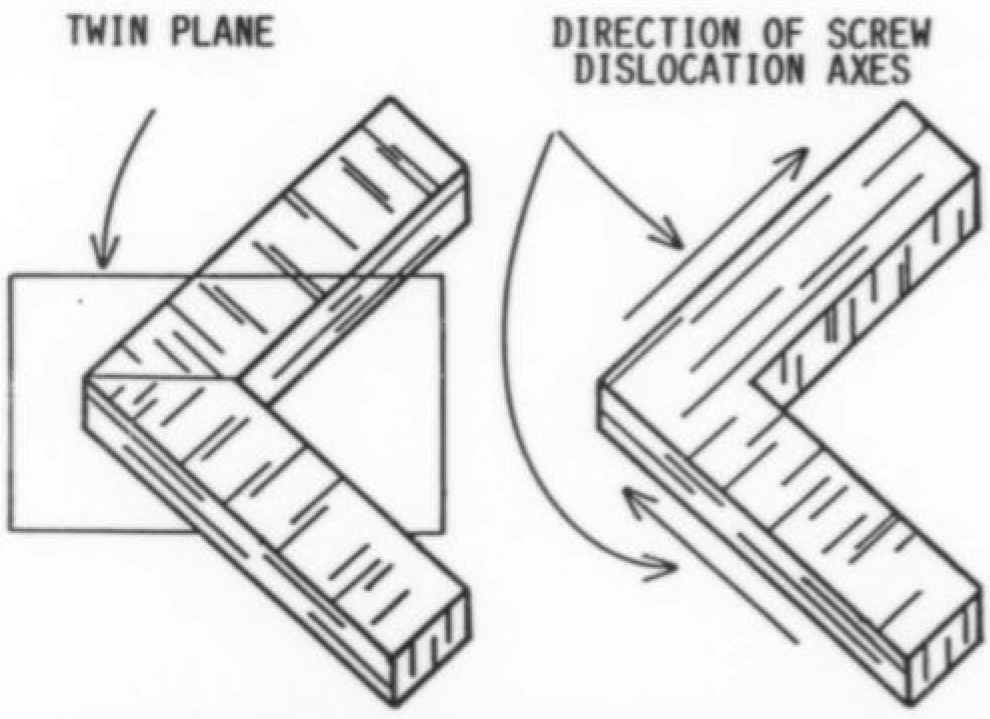

***Figure 16.* Direction of striations in the two legs of columnar pyrite crystals caused by twinning on (110) (left), and by birth and death of screw dislocations (right).**

the crystal is not twinned, the direction of the striations would be unchanged from one leg of the pyrite to the other (Fig. 16, right). Although truly filiform pyrites such as those shown earlier seldom if ever show striations, certain thicker right-angle-bend pyrites do. Examples from Watertown, Connecticut and Millersville, Pennsylvania (Figs. 17 and 18, respectively) do show such striations, and they are continuous and parallel across the right angle bend. It is the authors'

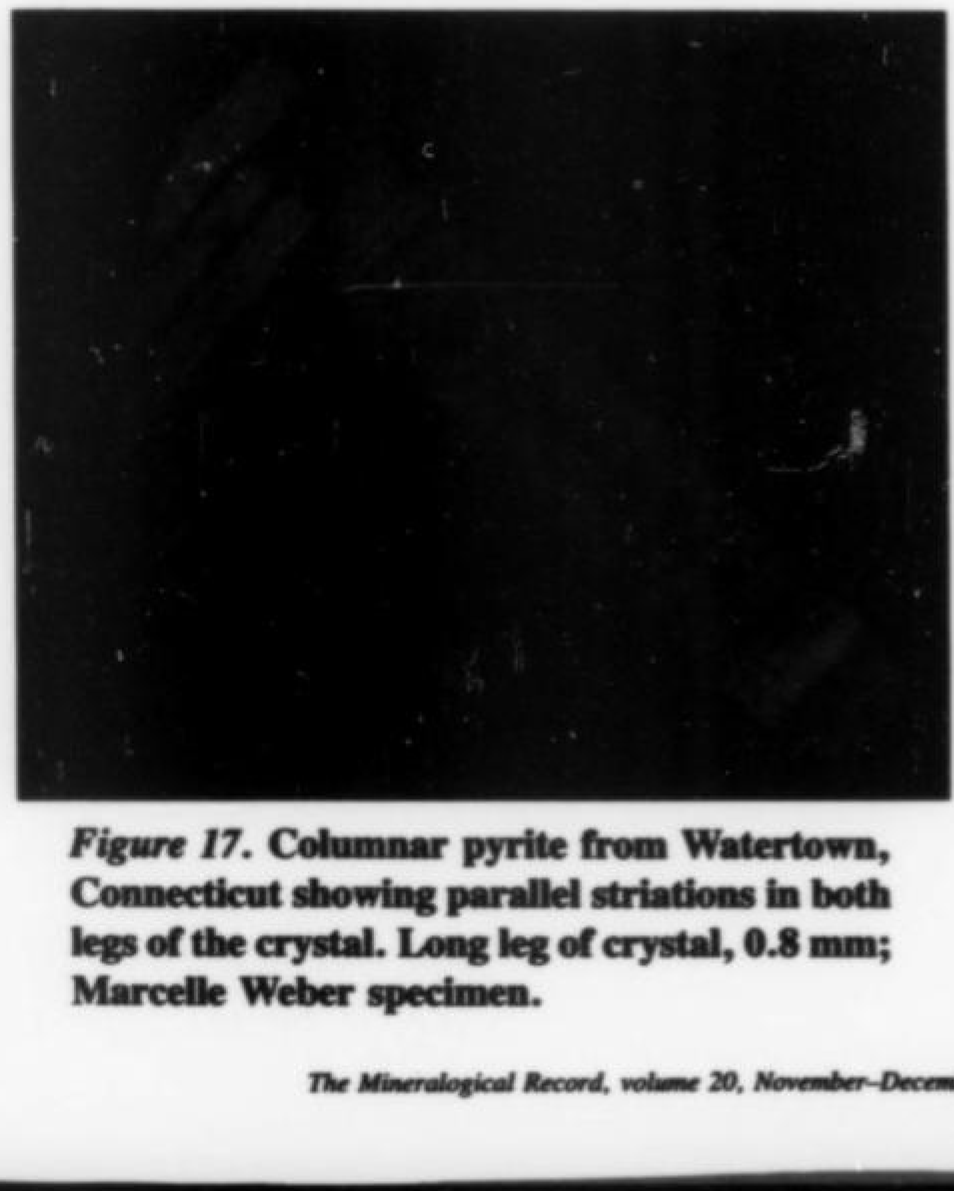

***Figure 17.* Columnar pyrite from Watertown, Connecticut showing parallel striations in both legs of the crystal. Long leg of crystal, 0.8 mm; Marcelle Weber specimen.**

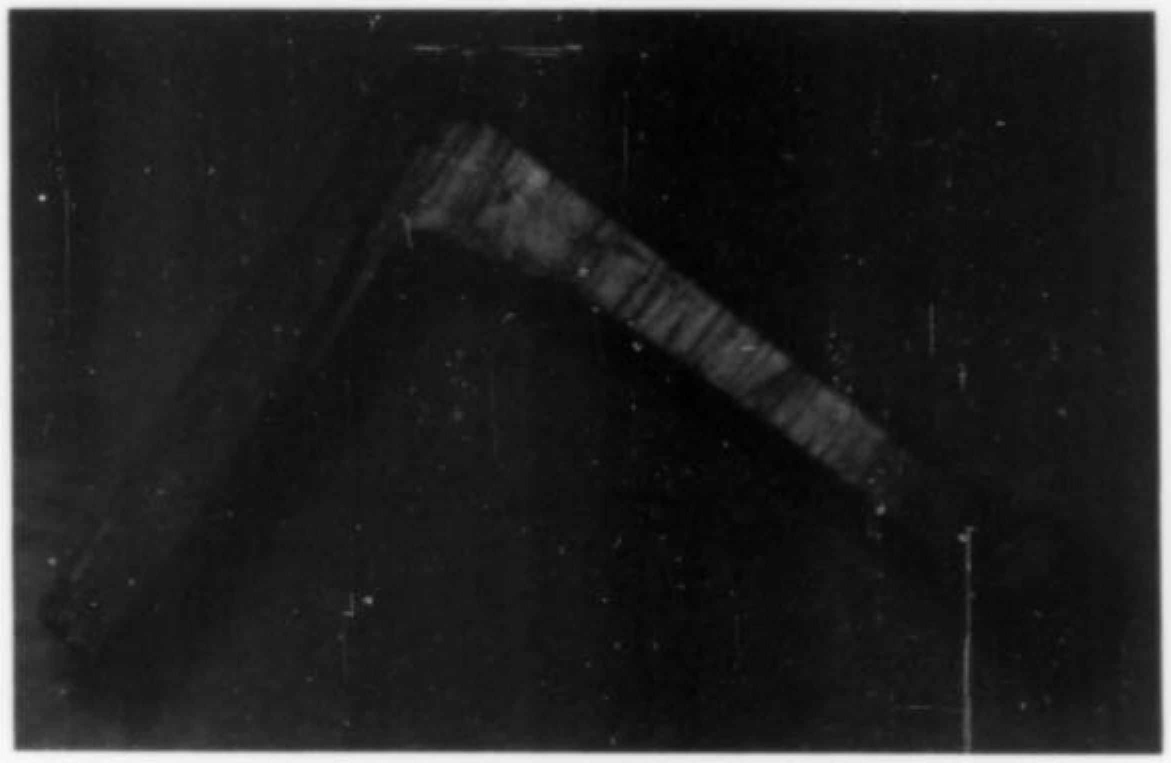

Figure 18. **Columnar pyrite with parallel striations in both legs of the crystal, from the H. R. Miller quarry, Millersville, Pennsylvania, longer leg, 0.9 mm; Bryon Brookmeyer specimen.**

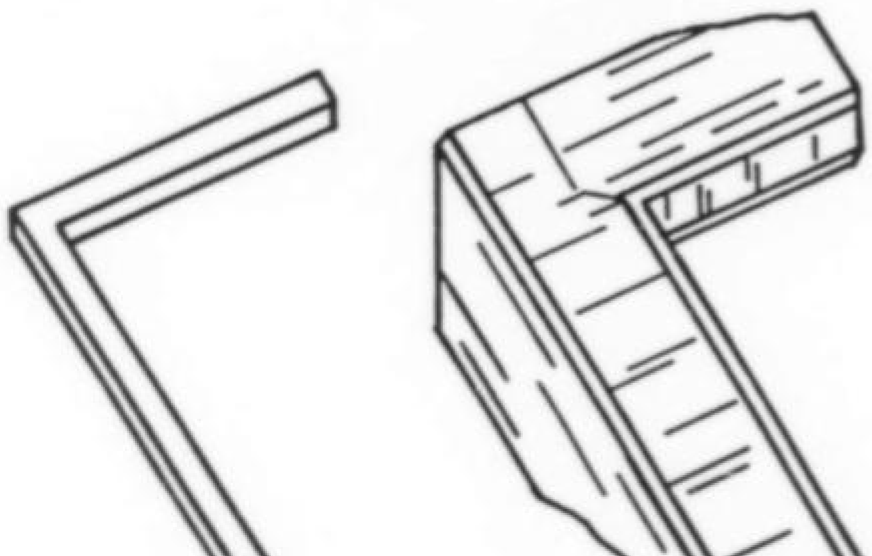

Figure 19. **Growth of whisker pyrite crystal with right-angle bend (left), followed by lateral thickening and appearance of striae (right).**

contention that these somewhat thicker crystals were originally much thinner (of the type shown earlier) and that they subsequently underwent a second period of lateral growth during which the striations appeared (Fig. 19). The striations indicate that the right-angle bends do *not* involve twinning.

White's paper (1973) on columnar pyrite from Naica, Mexico, documents just such a period of subsequent thickening of acicular pyrite as proposed here. He etched columnar pyrites growing through calcite crystals to expose a filiform neck within the calcite and connecting the thicker ends of the crystal. Thus, he demonstrated the following sequence of events: (1) growth of a pyrite whisker crystal, (2) partial enclosure of the pyrite within calcite, and (3) thickening of the exposed ends of the pyrite whisker during a second period of growth. A similar sequence of events explains the pyrite crystal transfixing calcite shown in Figure 20.

The two-fold symmetry of pyrite shown by striations on the cube faces is merely an external manifestation of the two-fold symmetry of the unit cell. More convincing than the morphological evidence just cited, is X-ray diffraction evidence demonstrating the absence of four-fold symmetry at the twin boundary. Precession goniometric methods for identifying twins have been described by Donnay *et al.* (1955) and have been used to prove that remarkable "jack-like" trillings of pyrite from Wyoming, although giving every outward appearance of being twinned, are actually untwinned (Pabst, 1971). For the current study, right-angle-bend crystals of pyrite from Sugar Grove, West Virginia (H127155) and the Clackamas River, Oregon

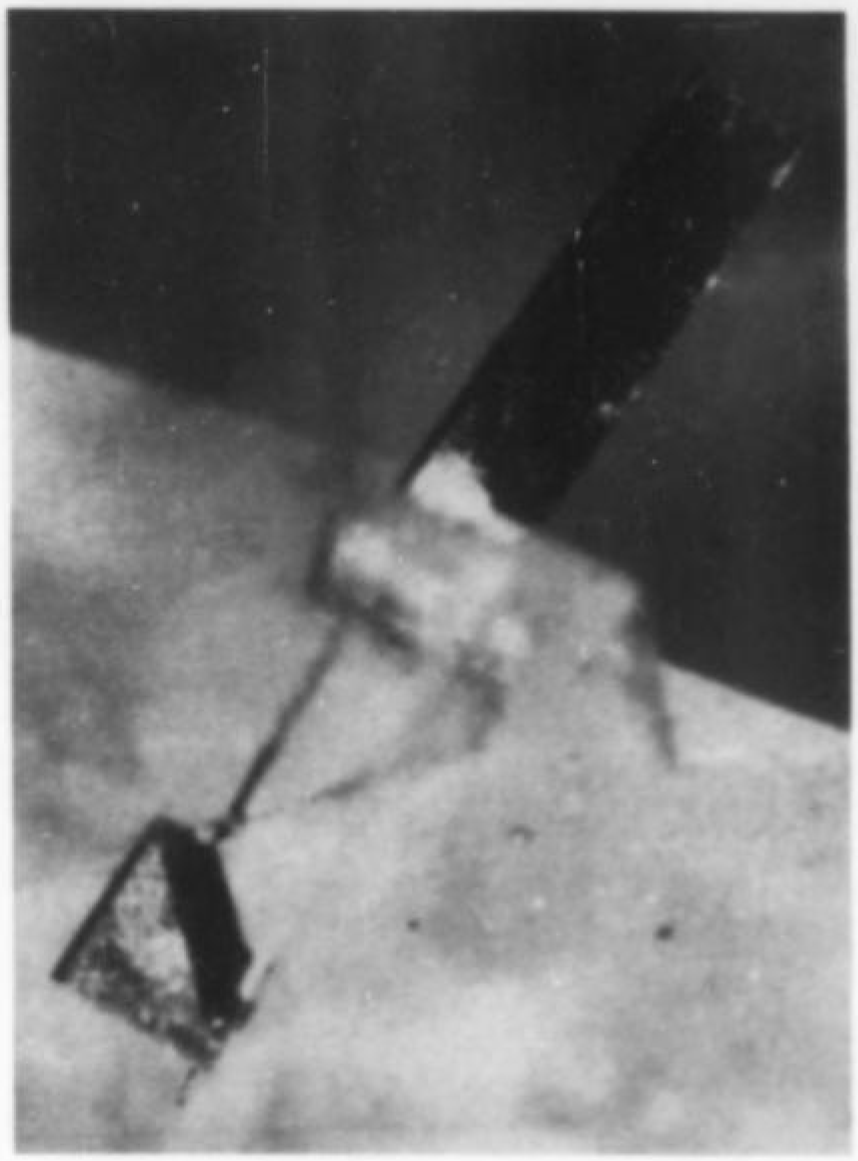

Figure 20. **Columnar pyrite crystal 1.4 mm long, from the Eureka Stone quarry, Eureka, Pennsylvania, showing (a) growth of whisker crystal, (b) enclosure of central portion of whisker by calcite and (c) lateral thickening of the ends of the pyrite crystal. Bryon Brookmeyer specimen; Omer Dean photo.**

(H127154) were studied by single-crystal X-ray diffraction. Zero-level, *a*-axis precession photographs of the bend areas (Fig. 21) clearly demonstrate two-fold rather than four-fold symmetry of the diffracted intensities. Both crystals are symmetrically distorted but untwinned cubes. Thus, bent pyrites from three different localities have been examined by X-ray diffraction and all have been found to be untwinned. We hypothesize that, upon examination, all others will also be found to be untwinned and that an alternative cause for right-angle bends in pyrite must be found.

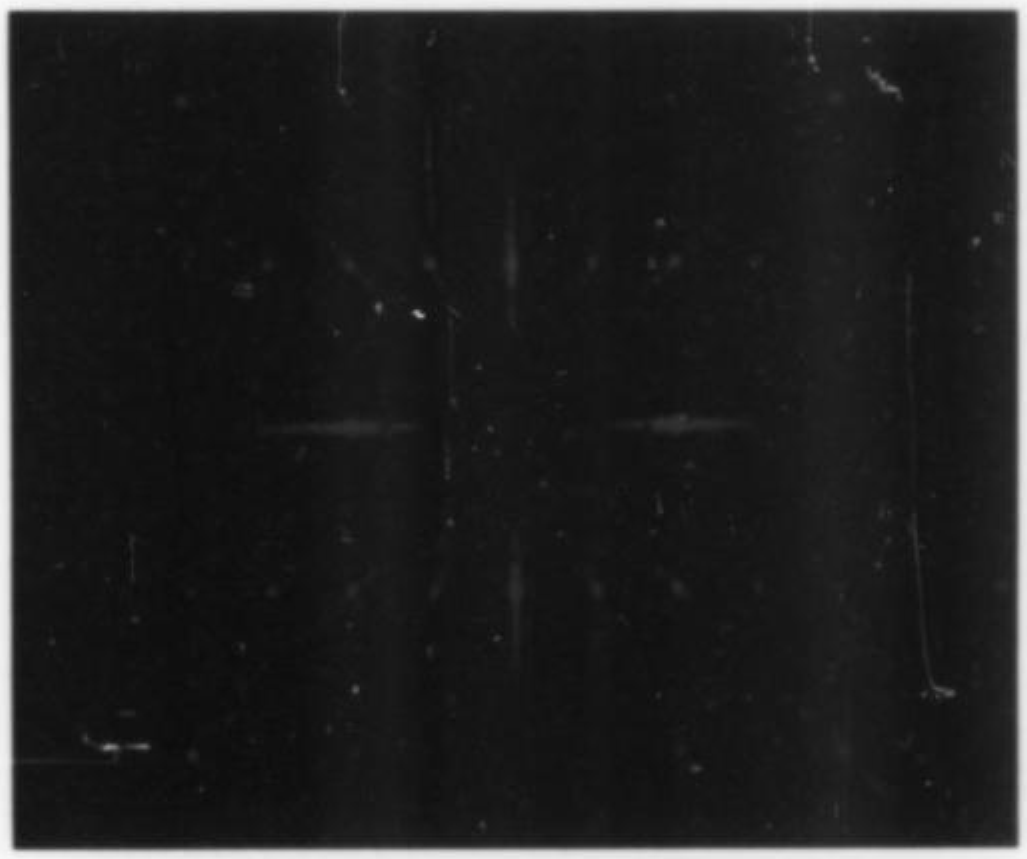

Figure 21. **Single-crystal X-ray diffraction photograph made with a precession camera of the bend portion of a pyrite from Sugar Grove, West Virginia. The diffraction pattern has only two-fold symmetry, while four-fold symmetry would be expected if the bend were a twin junction.**

SCREW DISLOCATION MECHANISM

An alternative mechanism for the formation of right-angle bends can be developed as a consequence of a theory first proposed by F. C. Frank in 1949 to explain the growth of acicular crystals of otherwise equant organic and inorganic phases. Good explanations of this theory, which is based on rapid growth in the direction of screw dislocations in the crystal, are to be found in several books, including Strickland-Constable (1968), and Doremus *et al.* (1958). Parenthetically, it should be mentioned that there are also several other mechanisms whereby filiform crystals of otherwise equant minerals can be formed, in nature or in the laboratory, and these too are described in the same references.

Frank proposed an explanation for the fact that acicular crystal growth can occur at degrees of supersaturation far below those required for initiating new growth layers in a perfect crystal. This is made understandable with reference to Figure 22. An increment of material accreted to a growing face at point 1 (Fig. 22a) is attached only at the base, and hence is easily removed. Material accreted at point 2 is more firmly attached since it is joined on both the base and one side. More firmly attached still is material accreted at point 3, which is joined to the crystal on three sides. It is clear, then, that at some low degree of supersaturation, material will accrete more rapidly at point 3 than at point 2, and more rapidly at point 2 than at point 1. Hence, a growth layer, once started, is rapidly completed, but the initiation of a new growth layer by attachment of material at points such as 1 is very slow or even impossible at low degrees of supersaturation. Consider, then, a small crystal which contains an imperfection such as that shown in Figure 22b. Such an imperfection is known as a screw dislocation and, while it is considerably strained at its center, the great bulk of the crystal, which would extend orders of magnitude further in the horizontal plane than as drawn in Figure 22b, would have the same stability and orderliness as a perfect crystal. Frank proposed that the presence of such screw dislocations would allow accretion of material to the growing crystal in continuously ascending spirals which would avoid the necessity for constantly forming new growth layers. His proposal for growth of crystals under low degrees of supersaturation is supported by the frequent observation of growth spirals in natural crystals.

It was left to Sears (1953) to observe that, if a crystal were nearly perfect, i.e., contained only a single screw dislocation, growth under conditions of low supersaturation would be extremely rapid in the direction of the dislocation axis, but might be extremely slow or nonexistent in other crystallographic directions. This, he proposed, would lead to the formation of acicular crystals of equant phases or minerals, as in Figure 22c. In the case of pyrite, growth of a crystal with a screw dislocation emerging from a cube face would produce a greatly elongated crystal bounded only by cube faces, as in Figure 22c.

Such acicular crystals containing screw dislocations can be grown in the laboratory. Sodium chloride whiskers grow readily from aqueous solution containing minute amounts of water-soluble polymers (Evans, 1957). When first formed, the crystals are elongated cubes as much as a centimeter long and so thin as to be undetectable under a high-power light microscope. At first, they may be curved, but they straighten as material later accretes on their sides. The polymeric material acts either by poisoning certain of the growth surfaces or by making the growth solution more viscous. (It is interesting to recall that pyrite whiskers or filiform crystals are often smoothly curved. These crystals are usually but not always attached to the vesicle walls at both ends, and have probably been fixed in their curved form by such attachment before any crystal thickening occurred.)

There are certain constraints on the growth of acicular crystals by this mechanism. The degree of supersaturation of the surrounding fluid must be very low so as to allow growth only parallel to the screw axis. Also, such growth is most likely to be seen in very small crystals, because the probability of appearances of growth defects increases with increasing crystal size or volume. Note that the pyrite crystals illustrated thus far are small, and their formation under conditions of low temperature is consistent with crystallization from slowly cooling solutions at low degrees of supersaturation. Interestingly, Sears' theory predicts that under similar growth conditions, a crystal with screw dislocations in only two directions would have a ribbon-like or tabular habit, and many such crystals of pyrite are illustrated here.

These comments are confirmed by experiments by Murowchick and Barnes (1987), who investigated the effect of temperature and degree

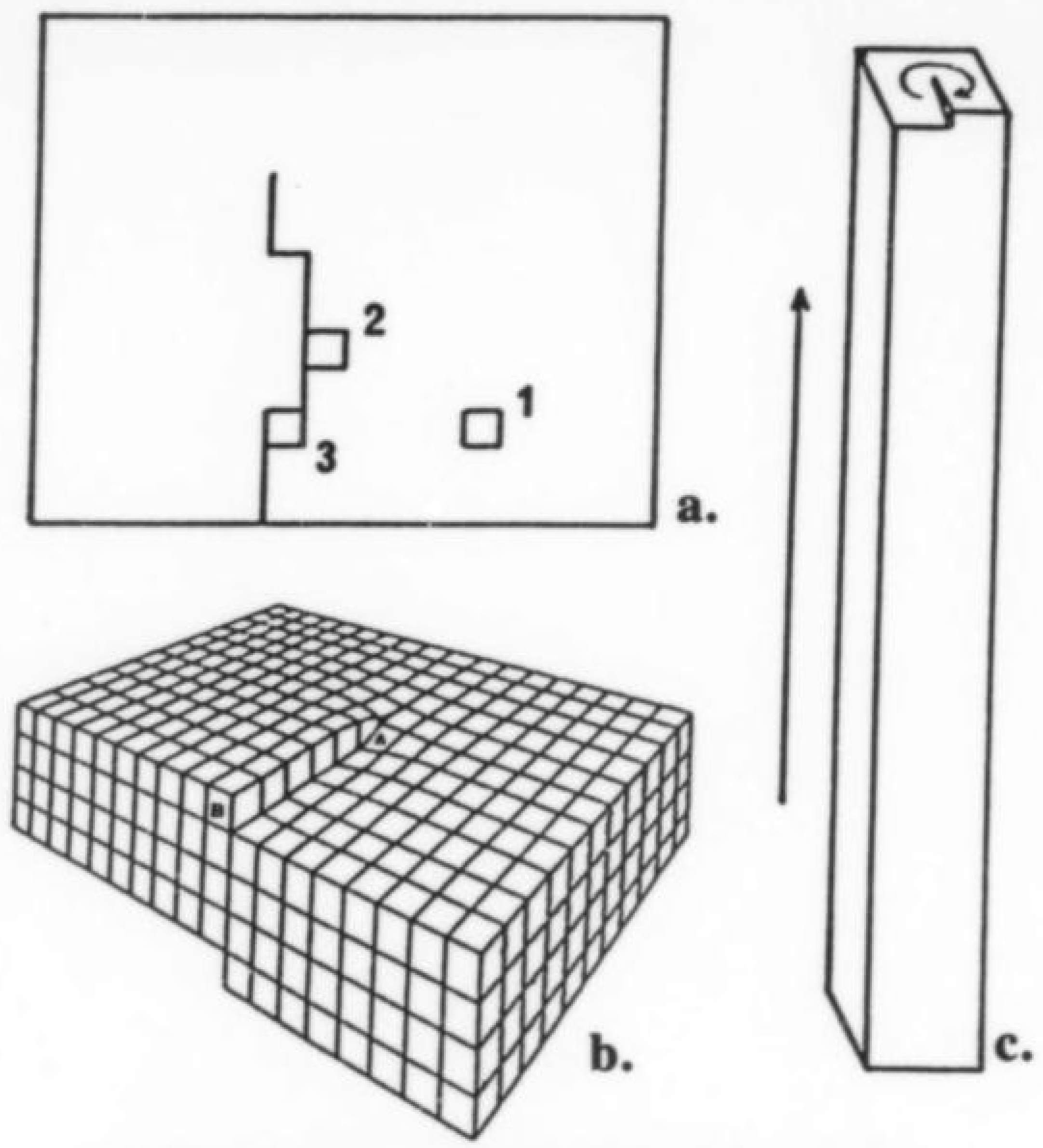

Figure 22. **Screw dislocations as a possible cause for the formation of acicular pyrite crystals: (a) accretion of material at various positions on an incomplete growth layer lacking dislocations; (b) a single screw dislocation in a crystal; (c) acicular crystal formed by rapid growth parallel to a single screw dislocation.**

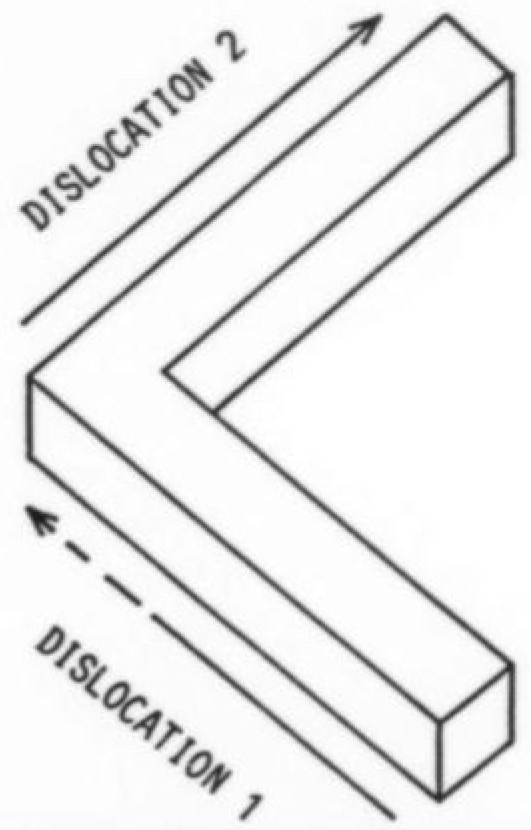

Figure 23. **A possible explanation for the formation of right-angle bends in filiform pyrite. Initial growth parallel to screw dislocation 1, followed by death of the dislocation and random birth of another at right angles to the first, produces the first and second legs of the single crystal with a right-angle bend between them.**

Table 1. **Occurrences of acicular pyrite showing right-angle bends.**

		Source
A. Basalt, Diabase Localities		
California	1. Hutchinson quarry, Greenbrae, Marin County	Violet Frazier
	2. Near Point Arena, Mendocino County	Violet Frazier
Connecticut	3. Cinque quarry, East Haven, New Haven County	Marcelle Weber
New Jersey	4. Haledon, Passaic County	White (1973); W.A.H., Jr.
Oregon	5. Agate Beach, Lincoln County	Violet Frazier
	6. Cape Lookout, near Sandlake, Tillamook County	Violet Frazier
	7. Clackamas River, near Estacada, Clackamas County	White (1973); Jean Downing
	8. Maxwell Point, near Oceanside, Tillamook County	Violet Frazier
	9. Near Mount Hood, Hood River County	W.A.H., Jr.
	10. Ritter, Grant County	Violet Frazier
West Virginia	11. Sugar Grove, Pendleton County	Erich Grundel; Fred Schaefermeyer
Washington	12. Rock Island Dam, Columbia River, near Wenatchee, Douglas County	Roberts *et al.* (1974); Violet Frazier
Australia	13. Narre Warren, Victoria	Jon Mommers
New Zealand	14. Dargaville, Hobson County, North Island	Neville Berkahn
	15. Lyttelton Harbor Board quarry, Lyttelton Borough, South Island	Ruth Jacobsen; Jean Jenks
B. Gneiss Localities		
Connecticut	16. Thomaston Dam, Thomaston, Litchfield County	Wolfgang Mueller; Marcelle Weber
	17. Watertown, Litchfield County	Marcelle Weber
Austria	18. Grieswies	Weiner (1980); Weiner *et al.* (1983)
	19. Vorsterbachtal, Rauris	Niedermayr & Seemann (1975)
Italy	20. Gallena, Apuane Alps, Liguria	Orlandi *et al.* (1982)
Switzerland	21. Near Hohtenn, Valais	Graeser (1984)
West Germany	22. Merzhausen, Hexental, near Freiburg	Widemann (1985)
C. Limestone, Dolomite, Marble Localities		
Kentucky	23. Halls Gap, Lincoln County	White (1973); Roberts *et al.* (1974); Violet Frazier; Wolfgang Mueller; Omer Dean
Missouri	24. Saint Francisville, Clark County	Sinotte (1969)
New York	25. Newark Cement Company quarry, Rondout, Ulster County	Whitlock (1905)
Pennsylvania	26. H. R. Miller quarry, Millersville, Lancaster County	Bryon Brookmeyer
	27. Eureka Stone quarry, Eureka, Bucks County	Bryon Brookmeyer
Canada	28. Steetly quarry, Dundas, Ontario	Neal Yedlin; Anderson (1979)
Mexico	29. Naica, Chihuahua	Bariand (1976); White (1973)
Switzerland	30. Termen, near Brig, Wallis	de la Rue and Graeser (1968)
D. Clay, Shale, Slate Localities		
Ohio	31. Huron River, west of Milan, Erie County	R. Peter Richards
	32. Huron River, near Monroeville, Erie County	R. Peter Richards
Utah	33. Mt. Carmel Junction, Kane County	Wolfgang Mueller
Switzerland	34. Near Mittal, Valais	Graeser (1984)
West Germany	35. Schnaittach, Franken, Bayern	Wilkzek (1983); Weiner *et al.* (1983)

of supersaturation on the morphology of pyrite grown in the laboratory. They found that pyrite grown at 250°C and at a low degree of supersaturation assumed an acicular habit, and they postulated (but did not demonstrate) that screw dislocations were responsible for such growth. Higher temperatures and/or higher degrees of supersaturation result in equant crystals of pyrite with cube, octahedron and/or pyritohedron faces.

A recent study of cuprite by Veblen and Post (1983) supports by analogy our proposal that filiform pyrites form by rapid growth parallel to screw dislocations. They were able to show, by transmission electron microscopy, that whisker crystals of the fibrous variety of cuprite with square cross sections contain screw dislocations running parallel to their length, and they postulated that the screw dislocations were responsible for the extreme elongation of the cuprite crystals.

How, then, can such crystals form right-angle bends? At least two mechanisms come to mind. First, a screw dislocation, which need not be propagated parallel to a crystallographic axis, might migrate to a side face of the growing acicular crystal and die out. If by chance a new screw dislocation were to form on a different cube face its axis would be perpendicular to the first, and it would promote rapid growth of the second leg of the crystal parallel to a second *a* axis. This mechanism is illustrated in Figure 23. Second, it may be that a screw dislocation can migrate to the edge of the rapidly growing cube face and, from there, to an adjacent cube face. There, it could initiate local, rapid growth of the latter face such that the new leg of the right angle bend would be formed. Still a third possibility has been proposed by Amelinckz (1958); it explains the formation of T-shaped right-angle bends in pyrite. Amelinckz has demonstrated the presence of screw dislocations in laboratory-grown acicular crystals of halite, and has shown that T-shaped individuals are probably formed by bifurcation of the screw dislocation in the first-grown leg of the crystal. All three of the above mechanisms may have operated to produce the specimens illustrated. Note that these screw dislocation mechanisms explain not only the right-angle bends but also the acicular habit of crystals, while the twin mechanism or other mechanisms for forming whisker crystals explain only the right-angle bends.

CONCLUSIONS

The authors conclude that (1) filiform pyrite is not uncommon in low-temperature, hydrothermal environments, (2) right-angle bends in filiform pyrite do *not* result from twinning, and (3) growth by the screw dislocation mechanism is sufficient to explain both their acicular habit and the formation of right angle bends.

ACKNOWLEDGMENTS

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Pyrophyllite from Ibitiara, Brazil

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INTRODUCTION

Pyrophyllite, $Al_2Si_4O_{10}(OH)_2$, occurs widely throughout Brazil but, because it is generally massive or fine grained, it has been sought mostly for industrial uses rather than for specimens. Interesting samples have previously been recovered from many quartz prospects and small mines in the Serra do Cabral northwest of Belo Horizonte, the capital of Minas Gerais. These are typically radial aggregates and sprays up to a centimeter or so, cream to pale brown in color, coating or partially included within transparent quartz crystals to several centimeters.

During the last ten years a number of prospects near the small town of Ibitiara in central Bahia have produced some outstanding specimens, which are the subject of this description.

THE IBITIARA AREA

Ibitiara lies about 400 km west-northwest of Salvador and northeast of Brasilia. Access is by way of the paved Salvador-Ibotirama road (BR242) as far as km 329 (or 145 km from the Boquira lead-zinc mine where a good landing strip is located). A good unpaved road extends for 23 km from the highway turnoff to Ibitiara, at an elevation of 900 meters.

The Ibitiara area is semi-arid, and covered by sparse, dry, low forest and many white anthills in the lowlands. Vegetation becomes thicker on the higher plains, with small patches of rain forest. The pyrophyllite prospects are located in a range of elongated, smooth-sloped mountains running north-south with transverse defiles. High cliffs are common in the area. Between the mountains are broad, humid valleys where the population lives by subsistence farming and digging for minerals.

Ibitiara is located on the western slope of the Chapada Diamantina, a quartzitic high plateau running north-south, to the west of Salvador. The town is world famous as a source of rutilated quartz crystals (Cassedanne, 1981). Occurrences of barite and cassiterite (Schobbenhaus, 1967), gem-grade andalusite (Cassedanne and Cassedanne, 1980), gold and bahianite (Cassedanne, 1985) are known to the south. See the latter reference and also Pedreira (1976) and Bruni and Schobbenhaus (1976) for a description of the regional geology.

At the base of the formations that comprise the Chapada Diamantina lies Unit One or the Rio dos Remédios complex, a westward-dipping volcanic sequence 2 to 4 km in width which crops out from Livramento do Brumado in the south to beyond Ibitiara in the north. It consists of quartz porphyry, rhyolites, rhyodacites, dacites, tuffs, breccias and some intercalated slates, conglomerates and quartzites mainly in the western area. The volcanic rocks are characterized by epizone metamorphism with local development of mylonites and sericite schists cut by quartz veins. Quartzite with lenticular basal conglomerates overlay the volcanic rocks.

Serra do Fogo do Caetano Prospects

The Serra do Fogo do Caetano prospects are located a short distance east-southeast of Ibitiara, near the upper edge of a cliff overlooking the Córrego da Fontinha valley (wherein the town is located). This occurrence produces the best pyrophyllite specimens.

Access is by way of the Ibitiara road for 3.5 km, then via a dirt road for 3.3 km to the conglomerate outcrops. From there another dirt road proceeds to the right, slowly climbing over a distance 5 km to the smooth-sloped Serra do Prego Mountain. Then a fork to the right leads up to the cliff and a second fork, to the left (both brush-covered), leads to the workings. The total distance from the Ibitiara road is 9 km.

A shallow open pit running east-west for about 30 meters has been cut through porphyritic volcanic rocks which dip 20°N. The excavation stripped out a pyrophyllite lens near the 1240-meter elevation level. About 20 tons of large pyromorphite crystals were mined from this pit and crushed to facilitate the removal of quartz impurities. Good samples can still be located with difficulty near the sorted piles.

Three hundred meters to the southwest, on the cliff edge at an elevation of about 1210 meters, a vertical vein contains veinlets of pyrophyllite blades to several centimeters in length. A 20-meter trench has stripped the occurrence and is now brush-covered. Wall rocks are vertically bedded quartzites cut by thin, northwest-trending quartz veins with a shallow northeastern dip; these veins contain small amounts of pyrophyllite.

The best pyrophyllite from these prospects occurs as sprays up to 12 cm in length, randomly oriented on volcanic or quartzitic matrix. "Roses" to several centimeters are common. Long blades occur mainly in quartz matrix. Cavities lined with thin crystals are rare. Associated minerals include hematite flakes, milky to transparent quartz crystals up to 8 cm in size, and, rarely, patches of lazulite. Exposed pyrophyllite crystals are beige, pale brown or reddish, but samples from deeper workings are pearl-white to cream-white.

Stratigraphically the pyrophyllite occurs in the same position as the cassiterite and barite occurrences nearby, that is, in the upper part of the volcanic sequence, below the conglomerate unconformity.

Agreste Prospect

The small Agreste prospect is located near those mentioned above. Access is by the same dirt road for 3.6 km, passing a fork at 1.9 km which leads to Macacos. Then a pack-trail passable to 4-wheel drive Jeeps leads to the right for 1.6 km to the occurrence in a valley at 1140 meters, at the end of a short footpath.

Here pyrophyllite occurs as fine grained lenses several meters in size associated with milky quartz. It has been exploited by three small, irregular excavations for the purpose of recovering compact, massive pyrophyllite suitable for carving.

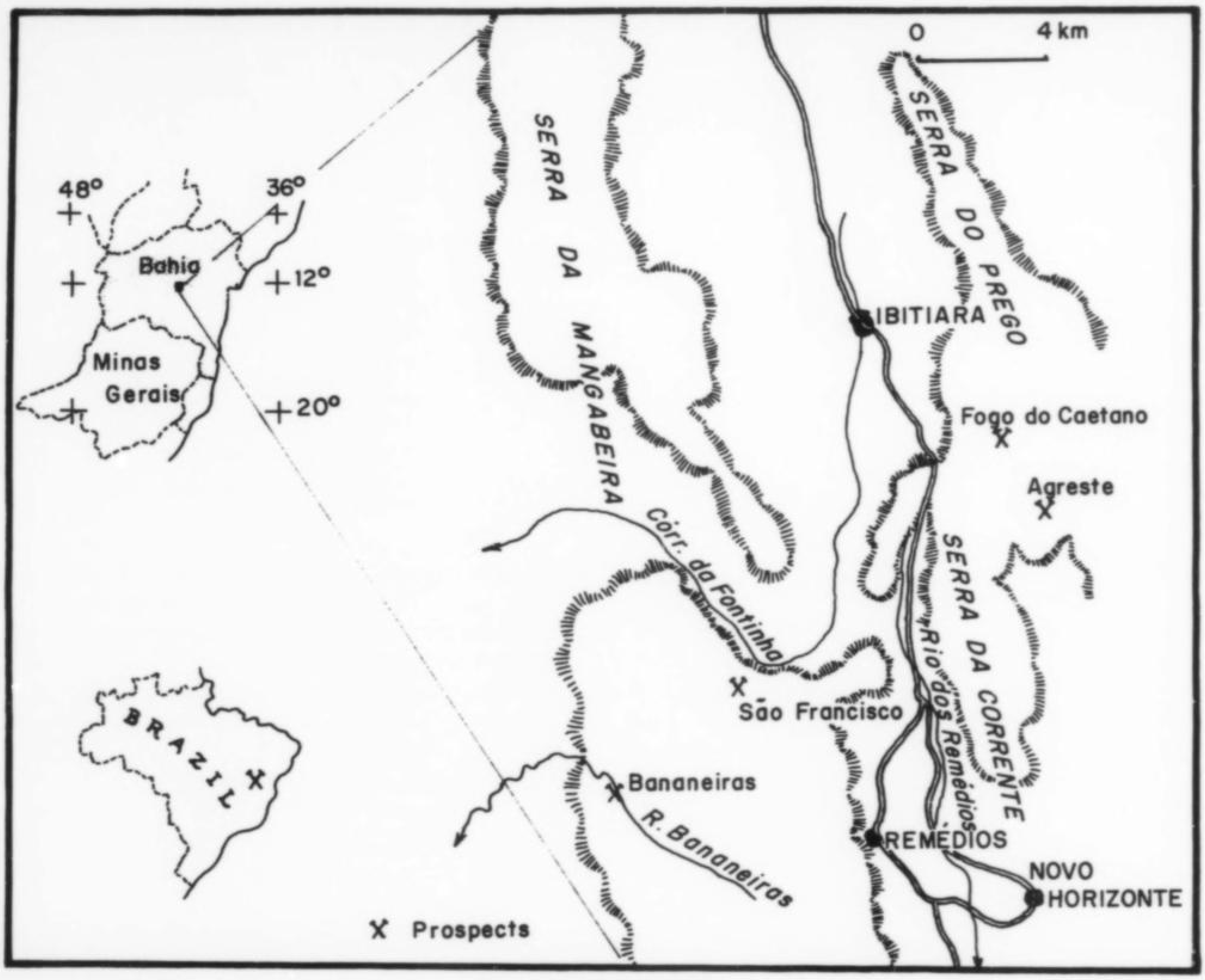

Figure 1. **Location map.**

Figure 2. **Pyrophyllite blades to about 6 cm,** ***in situ*** **at Serra do Fogo do Caetano.**

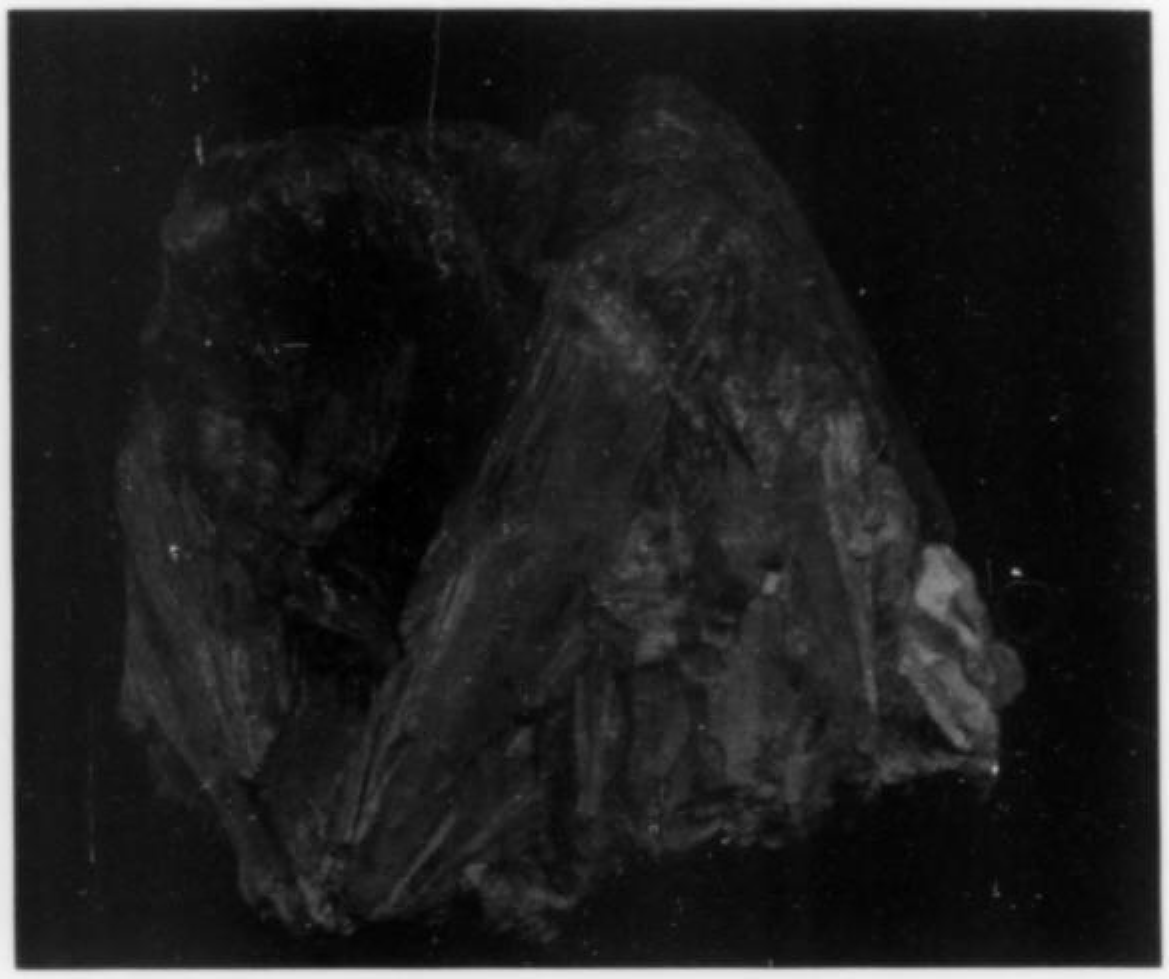

Figure 3. **Large group of pyrophyllite blades, 13 cm, from the Serra do Fogo do Caetano prospect.**

Bananeiras Prospect

The Bananeiras prospect lies to the west-northwest of the small town of Remédios (elevation 860 meters), in a north-south section of Bananeiras Creek (Riacho Bananeiras), near the margin of Mangabeira Mountain overlooking the Paramirim Valley lowlands. Access is by horseback only, from Remédios, which is 18.5 km by road from Ibitiara. The trail passes the old Baixinha and Tabuleiro barite workings and the small hamlet of Pinga. The horseback ride from Remédios to the occurrence is about 3 hours, through a nearly deserted area of thick, dry, low forest. Volcanic rocks can be seen cropping out along the trail, but quartzites appear only in the vicinity of the prospect.

The occurrence is a quartz vein several meters thick which strikes N50°W and dips north 75–80°. This vein cuts across quartzites trending north-northwest and dipping 30° to the northeast. Pyrophyllite is scattered through the vein as blades up to 8 cm in length and as coarse

***Figure 4.* Pyrophyllite sprays, 12 cm across, from the Serra do Fogo do Caetano prospect. All photos and specimens: J. Cassedanne.**

grained nodules. A little clay and abundant iron oxides are associated. The vein has been prospected by blasting.

São Francisco Prospect

The São Francisco prospect is located northwest of Remédios in a high, undulating area covered by thick brush. Access from Remédios is via horseback for 3 hours, passing the Tabuleiro quartz prospect and the little hamlet of São Gonçalo.

The occurrence is a north-south trending pyrophyllite layer, dipping 70° to the southeast, embedded in brownish quartzites. It has been explored by two trenches crossing the outcrop. The pyrophyllite is mostly fine grained, with scattered larger crystals up to 6 cm in length. Milky quartz and green andalusite (rarely of gem grade), in patches and veinlets, are associated.

NOTE

The Ibitiara map (SD-23-F-IV, 1/100,000 IBGE), whose accuracy is doubtful, may be used for general location. A digger from Remédios, whose nickname is Sulino, is an excellent guide to the western occurrences.

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An Occurrence of Orpiment at the Carlin Gold Mine, Nevada

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INTRODUCTION

The Carlin gold mine is located in sections 13 and 14, T35N, R50E, a part of the Lynn mining district, about 35 km north of the town of Carlin, Eureka County, Nevada. The large, open-pit mine and associated mill are currently owned and operated by Newmont Gold Company. Public access is prohibited.

Earliest mining in the Lynn district began in 1907 with the discovery of placer gold along Lynn Creek. The source of these placers, narrow quartz-gold veins, was soon discovered and in 1935 and 1936 yielded 15.5 kilograms of gold from small underground workings.

Newmont Mining Corporation began exploration for disseminated, sediment-hosted gold deposits in the area in 1961, attracted by Roberts' (1960) description of mineral deposits aligned along margins of "windows" eroded through the Roberts Mountains thrust. The Carlin deposit was discovered by exploration drilling in 1962, and mining and milling of ore began in 1964. The mine is now a series of connected pits (West, Main, South and East) that, in total, measure 2000 m long, 500 m wide and up to 200 m deep. Total production is estimated at just under 4,000,000 ounces of gold.

GEOLOGY

The geology of the Carlin mine is complex and has been described in detail by Hausen (1967), Radtke (1985) and many others. The ore zones are disseminated within the upper 250 m of silty dolomitic limestone of the Roberts Mountains Formation of Middle Silurian to Early Devonian age. Gold at Carlin occurs as micron-sized, native metal particles which were deposited by hydrothermal processes during the Tertiary period. Grades within the orebody range from more than 155.5 grams of gold per ton to an economic cutoff of 0.62 grams of gold per ton. Gold ores, both oxidized and carbonaceous, are commonly associated with arsenic, thallium and mercury minerals. Decalcification, silicification, and argillization are the dominant hydrothermal alteration types that affect the host lithologies.

The more than 500 meter thick Roberts Mountains Formation is overlain by a more than 150 meter sequence of massive Devonian limestone, locally known as the Popovich formation. This formation contains minor gold ore in structurally prepared areas near northwest-trending, high-angle normal faults that control gold distribution throughout most of the mine. The Popovich formation is in low-angle fault contact (the Roberts Mountains thrust) with overlying interbedded chert and shale of the Ordovician Vinini Formation (Fig. 1). At Carlin, the Vinini contains insignificant gold and few trace minerals.

OCCURRENCE

In November of 1983, a small fault dilation breccia was discovered in the East Pit of the Carlin mine, on the 6300-foot (1940 m) level near mine coordinates 23,950N; 20,450E (Fig. 1). This breccia rested within a small fault-controlled gold ore zone in limestone of the Devonian Popovich formation.

Unoxidized portions of the East ore zone at Carlin contain large amounts of arsenic, antimony, mercury and thallium. According to Radtke (1985), this has resulted in the formation of a relatively rare suite of minerals. These include realgar, orpiment, lorandite, getchellite, galkhaite, cinnabar, weissbergite, stibnite, christite, ellisite and the rare barium mineral frankdicksonite. Most of these minerals were associated with barite or quartz veins on mine benches 6320 through 6440, east to northeast of the orpiment breccia. The specimen localities were completely removed during gold mining operations.

The breccia was a small podiform body unique in its heavy concentration of arsenic sulfides. Local concentrations of arsenic minerals are common at Carlin, but very few are as well crystallized as this occurrence. About 900 kilograms of specimen-grade material were removed by hand before the site was mined and the ore sent to the mill. Orpiment crystals in the material were protected from the hazards of blasting by a filling of late-stage calcite. Some of this calcite was removed using dilute hydrochloric acid to reveal orpiment crystals.

A rough paragenesis of the occurrence would be: (1) deposition of limestone followed by regional tectonic activity (uplift and thrust faulting), (2) faulting/dilation and brecciation, (3) deposition of crystalline quartz, (4) deposition of arsenic minerals that accompanied gold mineralization, and (5) late filling of the breccia zone by calcite (Fig. 2).

Subsequent mining at Carlin (Fig. 3) has failed to expose any more material of this type. Final limits of the designed pit were reached in September, 1986.

MINERALS OF THE ARSENIC BRECCIA

Calcite $CaCO_3$

Calcite occurs as a white, translucent, massive, breccia matrix filling and as veins and veinlets. This material often displays pearly luster and perfect cleavage.

Gold Au

Micron to sub-micron sized native gold particles occur as disseminations grading up to 6.22 grams per ton within the limestone fragments of the breccia. Gold is detectable only through the use of a scanning electron microscope or by fire assay.

Orpiment As_2S_3

Occurs as lemon-yellow to brownish yellow, resinous, short, pris-

Figure 1. **General view of Carlin Mine looking east. Orpiment locality is out of view, around far corner, to left. 1986 photo by author.**

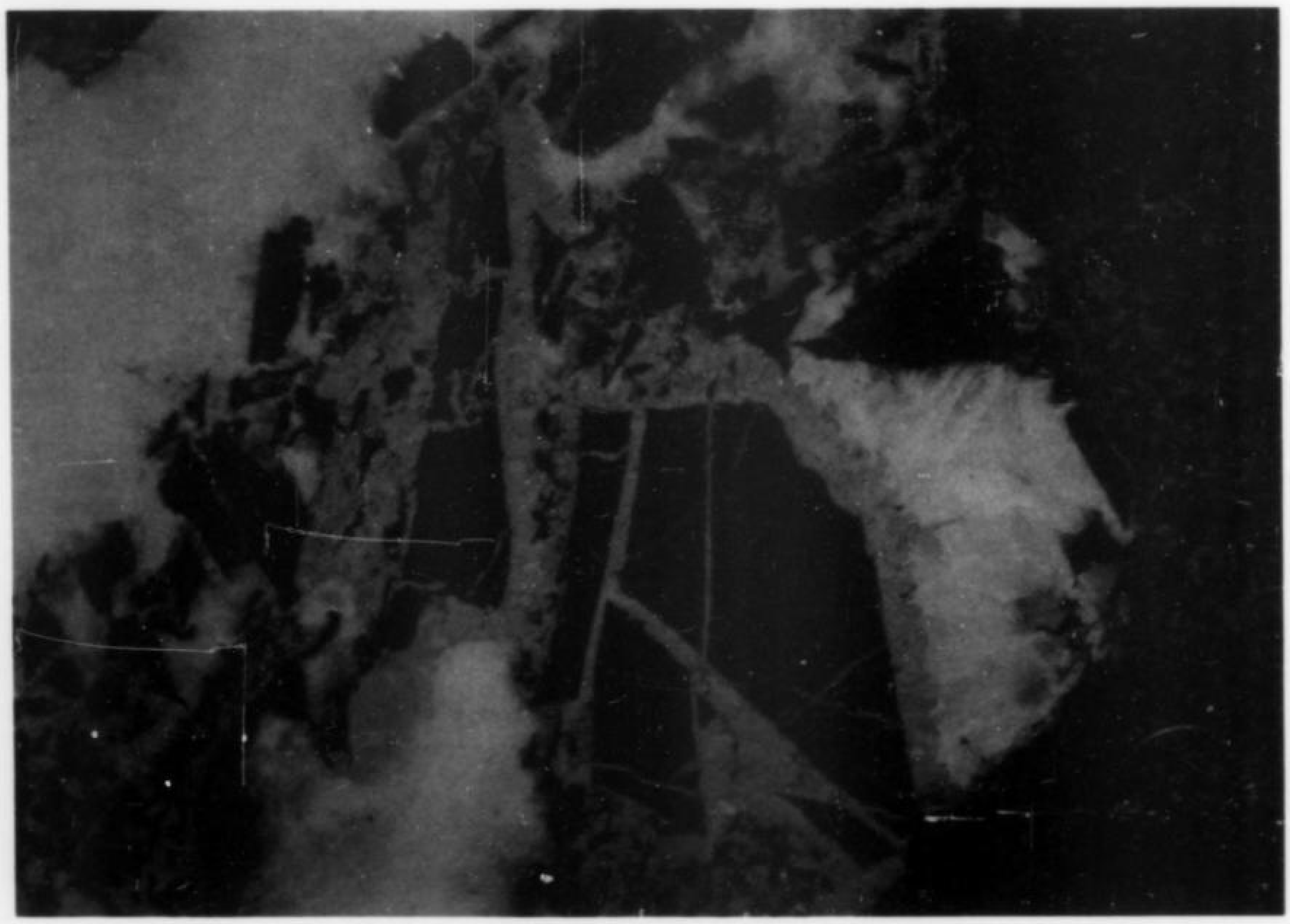

Figure 2. **Cut slab of breccia showing yellow orpiment crystals, red realgar, white calcite and black limestone breccia fragments. Specimen is 15 cm high. Photo by author.**

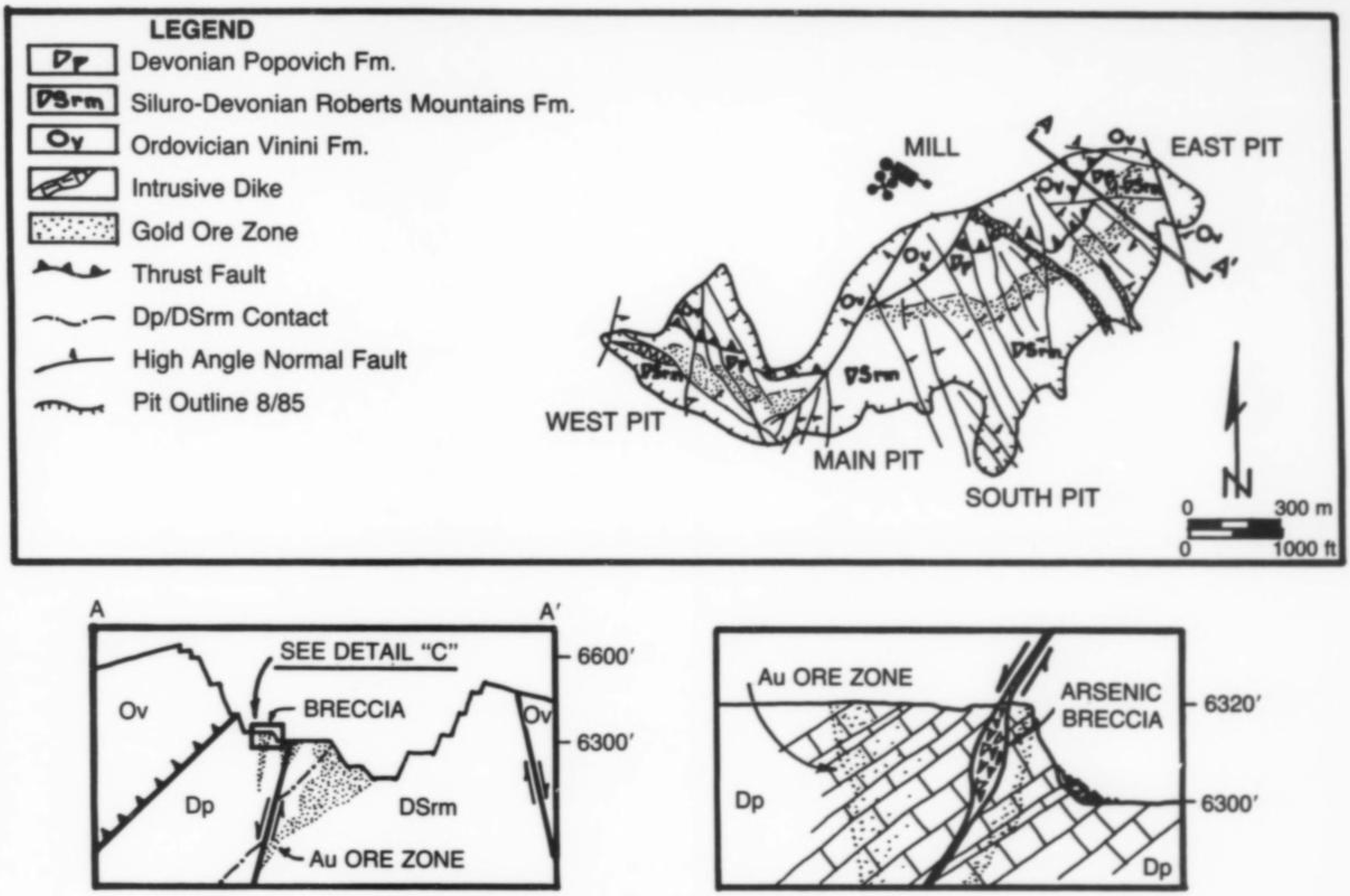

Figure 3. **Generalized geologic map of the Carlin gold mine (top); geologic section A-A' (lower left), Carlin mine east pit, looking northeast; geologic detail of breccia area (lower right).**

matic crystals that are elongated on the *c*-axis to about 5 mm. The orpiment is often seen coating the carbonaceous limestone breccia fragments, with some as radiating crystal groups and some as massive veinfill.

Quartz SiO_2

Milky white, short, hexagonal, doubly terminated, quartz crystals measuring up to 6.4 cm are present between breccia fragments. These subhedral to anhedral crystals were broken with an uneven fracture sometime before deposition of the calcite and arsenic minerals. Their occurrence is probably linked to late-Paleozoic thrust faulting, rather than Tertiary hydrothermal activity.

Realgar AsS

Occurring in direct association with the orpiment are short, prismatic realgar crystals, orange-red in color, translucent and measuring up to 4 mm in length. Crystals observed in the breccia alter to a yellow-orange color when exposed to light.

ACKNOWLEDGMENTS

The author would like to thank the management of Newmont Mining Corporation, Newmont Exploration Ltd., and Newmont Gold Company (formerly known as Carlin Gold Mining Company) for permitting the publication of this article. I would also like to acknowledge Walt Smith for drafting the maps used in this article and Don Hammer for his review and comments.

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PINT'S QUARRY
BLACK HAWK COUNTY, IOWA

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Pint's quarry, on the east edge of the town of Raymond, Iowa, has been a prolific producer of mineral specimens for several decades. Perhaps best known for its large brown fluorite crystals, Pint's has also offered a number of interesting habits of marcasite and a variety of other well-formed species.

INTRODUCTION

Pint's quarry was originally developed by Harold Pint and still bears his name. Over the intervening years, five other operators have worked the pit, which is now owned by the Basic Materials Corporation. The quarry is presently active. Production of aggregate for the concrete and road construction industries, in addition to larger material for riprap, comprise the primary business for the current operators.

GEOLOGY

Pint's quarry is located in an area known as the Iowan Erosion Surface, a landscape of low relief in northeast Iowa. In the vicinity of the quarry, bedrock is exposed in roadcuts and is covered by only a few meters of glacial till and surficial sediments.

Excavation at Pint's quarry has exposed more than 30 meters of the Devonian Cedar Valley Formation.* Included are 10 meters of the upper member (Coralville), 13 meters of the middle member (Rapid), and 9 meters of the lower member (Solon). The Solon Member is further exposed in the underground part of the workings. The most spectacular mineralization occurs in the Solon, which was first entered in 1964.

Kettenbrink (1972) has described the stratigraphy at Pint's quarry in some detail. Diagenesis is a striking feature, with extensive dolomitization and recrystallization of calcite. Silicification, although less abundant, is also widespread.

The Solon Member of the Cedar Valley Formation is thick-bedded to massive with numerous, irregularly spaced, discontinuous bituminous partings. Horizontal, unbranched, sinuous burrows are particularly common in the lower part of the Solon. While not as fossiliferous as other Solon sections in eastern Iowa, the Solon beds in Pint's quarry still contain abundant recognizable fossils and fossil fragments. Rugose corals are most common and favositid corals are also fairly common. Stromatoporoids, brachiopods, bryozoans and crinoid fragments are present as well.

The Solon-Rapid contact in the quarry is placed at a prominent burrowed discontinuity (Kettenbrink, 1972). The contact occurs a meter or two below the lowest bench of the workings and about 8 meters above the floor. The base of the Rapid Member consists of a lag concentration of phosphatic fish remains and glauconite pellets. The primary vug concentration in the quarry is found in the upper Solon and lower Rapid and is quite obvious even from some distance.

The top meters of the Rapid are characterized by contorted and deformed bedding. These irregularities were probably produced by gravitational slippage of soft or weakly consolidated carbonate muds. The Rapid at Pint's quarry has both horizontal and vertical burrows, and some of the beds have been churned up by burrowing organisms. Other beds preserve small-scale "cut and fill" structures, attesting to wave action at the time of deposition.

One of Pint's quarry's early advocates and explorers was the late Muriel Menzel. In the summer of 1969 she collected a small articulated

*Recently, changes in the nomenclature for Devonian strata in this area have been proposed. Cedar Valley has been elevated to group status and Coralville to formation status. Usage of Rapid and Solon is restricted to localities in east-central Iowa. Strata at Pint's, formerly included in the Solon and Rapid members of the Cedar Valley Formation, are now assigned to the Little Cedar Formation. Because these changes have not yet been published in detail, the existing nomenclature will be used in this article. The new interpretation was presented by Witzke, Bunker and Rogers (1987).

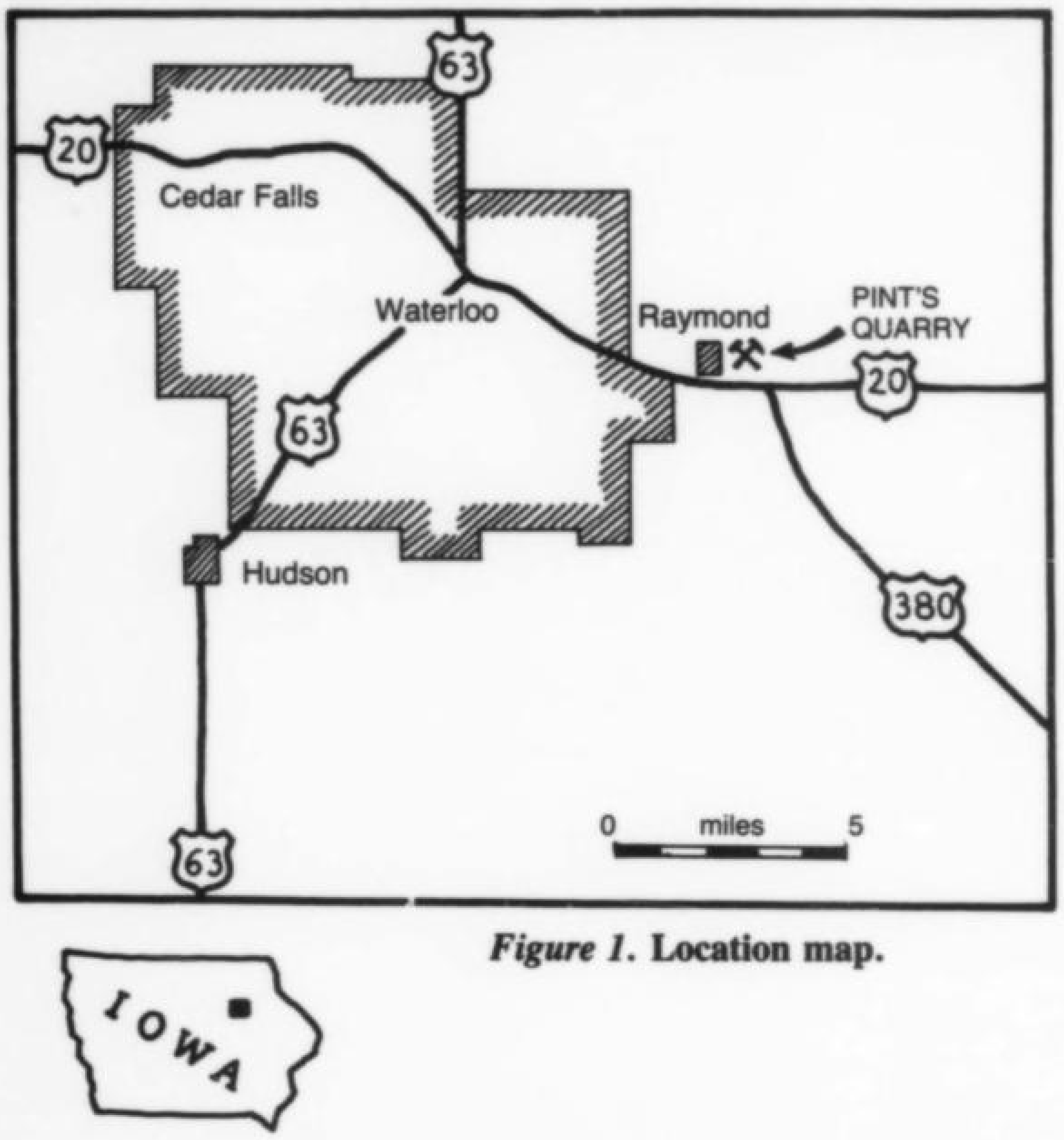

Figure 1. **Location map.**

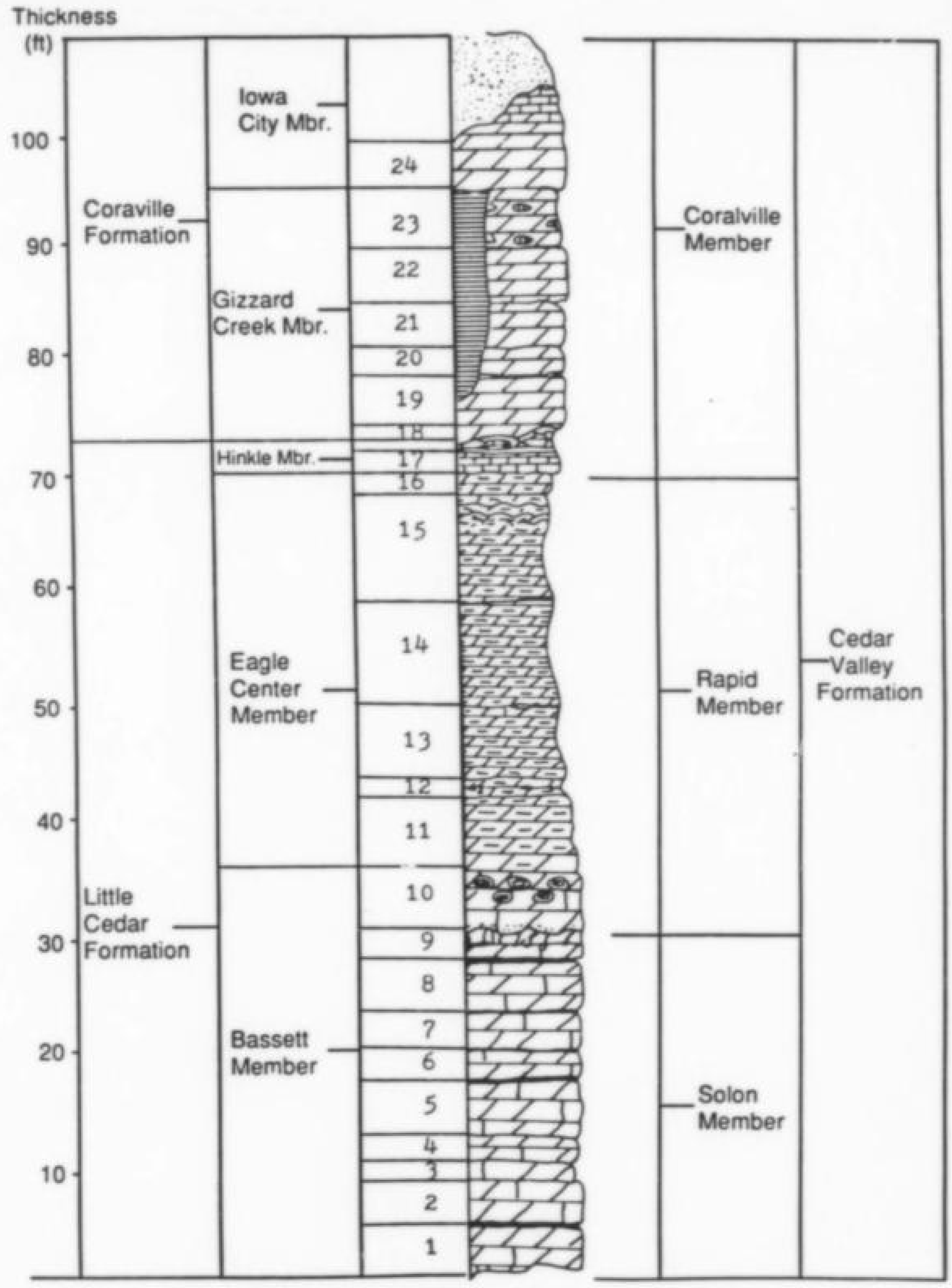

***Figure 2.* Stratigraphic section exposed in the vicinity of Pint's quarry. Revised nomenclature of Witzke *et al.* (1987) shown at left; nomenclature of Kettenbrink (1972) at right (from Bennett, 1988).**

placoderm fish from the Rapid Member. The fish, a new species, was described by Denison (1985) and named *Ptyctodopsis menzeli* in honor of Mrs. Menzel, thereby illustrating that a mineral collector need not discover a new *mineral* species to be immortalized.

The bulk of the Coralville Member at Pint's quarry consists of fine grained dolomite and limestone. Recrystallization and dolomitization have destroyed most of the original fabric of these rocks. Calcite-lined vugs are present in the Coralville, but other minerals are rare or absent.

MINERALIZATION

Mineralization at Pint's quarry has been studied and described by Garvin (1984), and much of the discussion that follows is summarized from his work. As far as composition is concerned, mineralization resembles that of the Upper Mississippi Valley (UMV) zinc-lead deposits. In other respects, however, there are significant differences. UMV deposits are fracture-controlled, while at Pint's, although fractures were important in controlling fluid migration, most mineralization is contained in vugs. Additionally, UMV deposits are characterized by early sulfides and late calcite, but at Pint's quarry the sequence is reversed.

All three members in the quarry are mineralized, giving evidence for fluid migration along a vertical plumbing system (Garvin, 1984). Mineralization is most varied and abundant, however, in the Solon due to its large amount of vugs and possibly the high organic content of that member. The iron sulfides from the Solon show an enrichment in nickel, copper and cobalt in comparison with the sulfides from the Rapid and Coralville members. According to Garvin (1984), the common association of nickel, copper and cobalt with carbonaceous material suggests that they, along with iron and sulfur, may have been derived locally from the Solon by circulating hydrothermal fluids. It is also possible that chemical reduction of these fluids was favored by the carbonaceous content of the Solon Member, causing precipitation and concentration of sulfides within the Solon.

Vug distribution appears to be determined by bedding plane fractures and by partially silicified corals (Garvin, 1984). Although many of the crystal-lined vugs in the Solon give no indication of their origin, a few do. These vugs have outer margins that are silicified, preserving the skeletal structures of various corals. After silicification of the outer parts of the corals, the remaining calcite skeletons were dissolved, producing voids. Subsequent mineralization of the pockets often occurred directly on the silicified coral.

Almost all the significant mineralization occurs in vugs, rather than in joints. Even though jointing is prominent in the host rock, the joints usually carry only an iron oxide stain.

Paragenetic relationships of the mineral species at Pint's quarry are complex because some minerals appear in more than one generation. These different generations can sometimes be distinguished on the basis of color, crystal habit and relationship to other minerals. For example, early pyrite, which is not abundant, is cubic, while late pyrite is cubo-octahedral or octahedral. It is difficult to place sphalerite, galena and gypsum in the paragenetic sequence with any degree of precision because of their rarity and general isolation from other minerals and from each other. Garvin (1984) has developed a paragenetic sequence for Pint's quarry, shown here.

MINERALS

Pint's quarry produces handsome specimens of fluorite, marcasite, pyrite and calcite, with sphalerite and barite often providing additional interest. It is not uncommon to find four well-crystallized species on a single miniature. Some of the following discussion is summarized from Lin (1978) and Garvin (1984), who have reported on the quarry's minerals.

Barite $BaSO_4$

Barite occurs fairly frequently in the quarry, almost always in

Figure 3. **A view of the quarry, 1988.**

association with calcite, fluorite and/or pyrite. The barite is generally colorless to white, rarely shading to very pale blue. The tabular crystals are often found in radiating aggregates. Barite crystals up to 2 cm in length are not uncommon, and the size can range upward to 8 cm or more. Often a second generation of smaller barite blades can be found upon earlier and larger barites. Although iron oxide staining at Pint's is most common on barite, fresh specimens can be found. The barite is extremely fragile and difficult to collect; most of the other species are relatively durable.

Calcite $CaCO_3$

Calcite is by far the most abundant mineral in the workings, and is often sufficiently attractive to be interesting in its own right. A high percentage of pockets in the quarry are completely lined with calcite crystals, which in turn are dotted with crystals of other species.

The calcite at Pint's quarry is usually colorless to white, with occasional pale amber-colored crystals or massive pieces. Infrequently, an entire vug of calcite will be covered with a thin dark brown film that gives an appearance of irridescence. Rarely do these vugs have additional mineralization. Pale pink calcite has been reported in association with sparry white calcite.

Because the vug size ranges up to half a meter, some large calcite crystals occur. While rare, perfectly-formed calcites up to 25 cm in length, commonly with included sulfides, have been found. As with the smaller crystals, the dominant form is the scalenohedron, sometimes modified by rhombohedra and prism faces. In the Coralville, calcite is characteristically rhombohedral in form, with crystals up to three cm in size. Barrel-shaped calcites consisting of scalenohedron and basal pinacoid faces also occur, but are uncommon.

A puzzling occurrence of calcite crystals with curved faces has been discovered at Pint's and described by Dickinson and De Nault (1981).

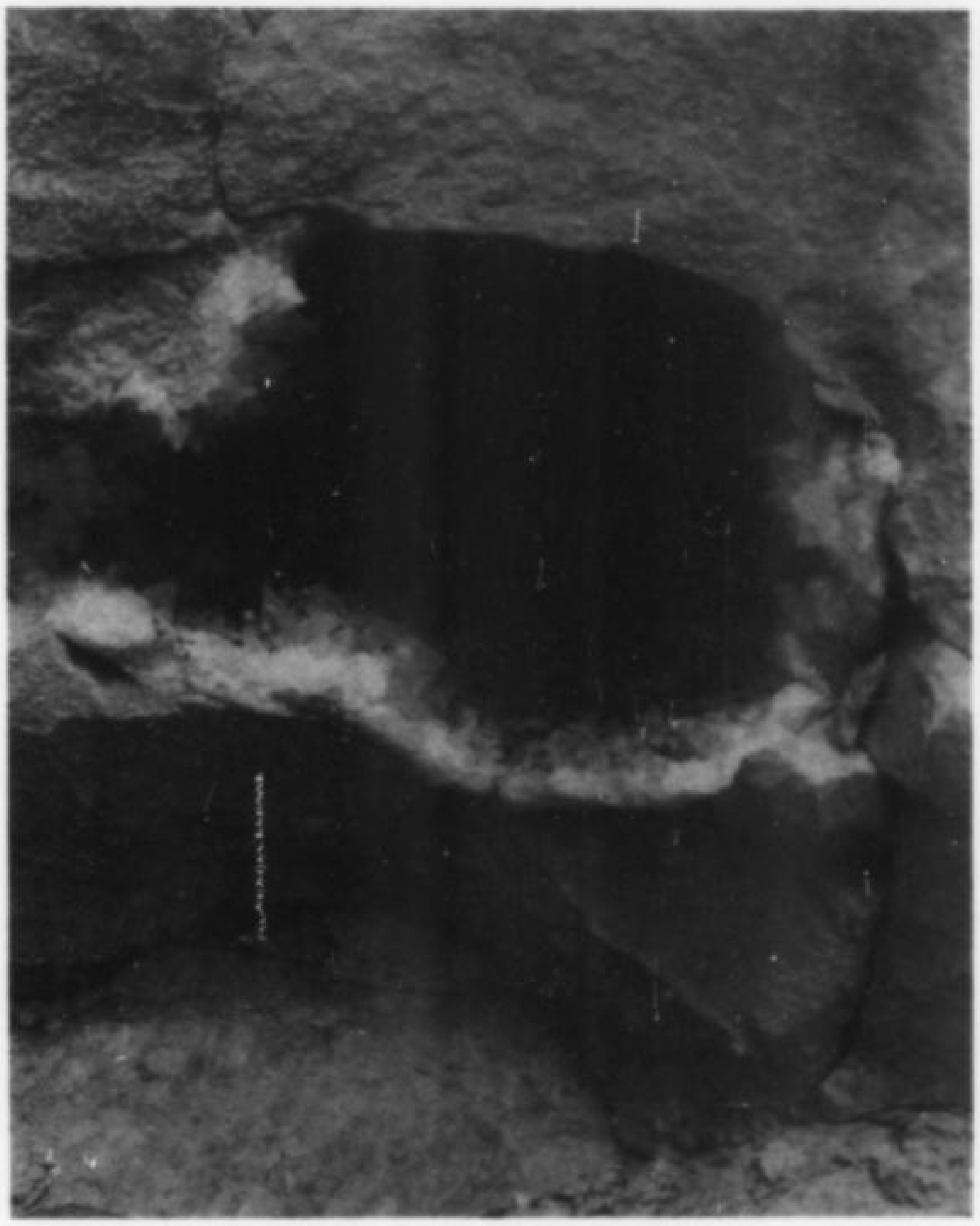

Figure 4. **A large calcite pocket (9 cm) in situ.**

Figure 5. White barite crystal cluster about 2 mm in diameter, on calcite, from Pint's quarry. Don Behnke specimen and photo.

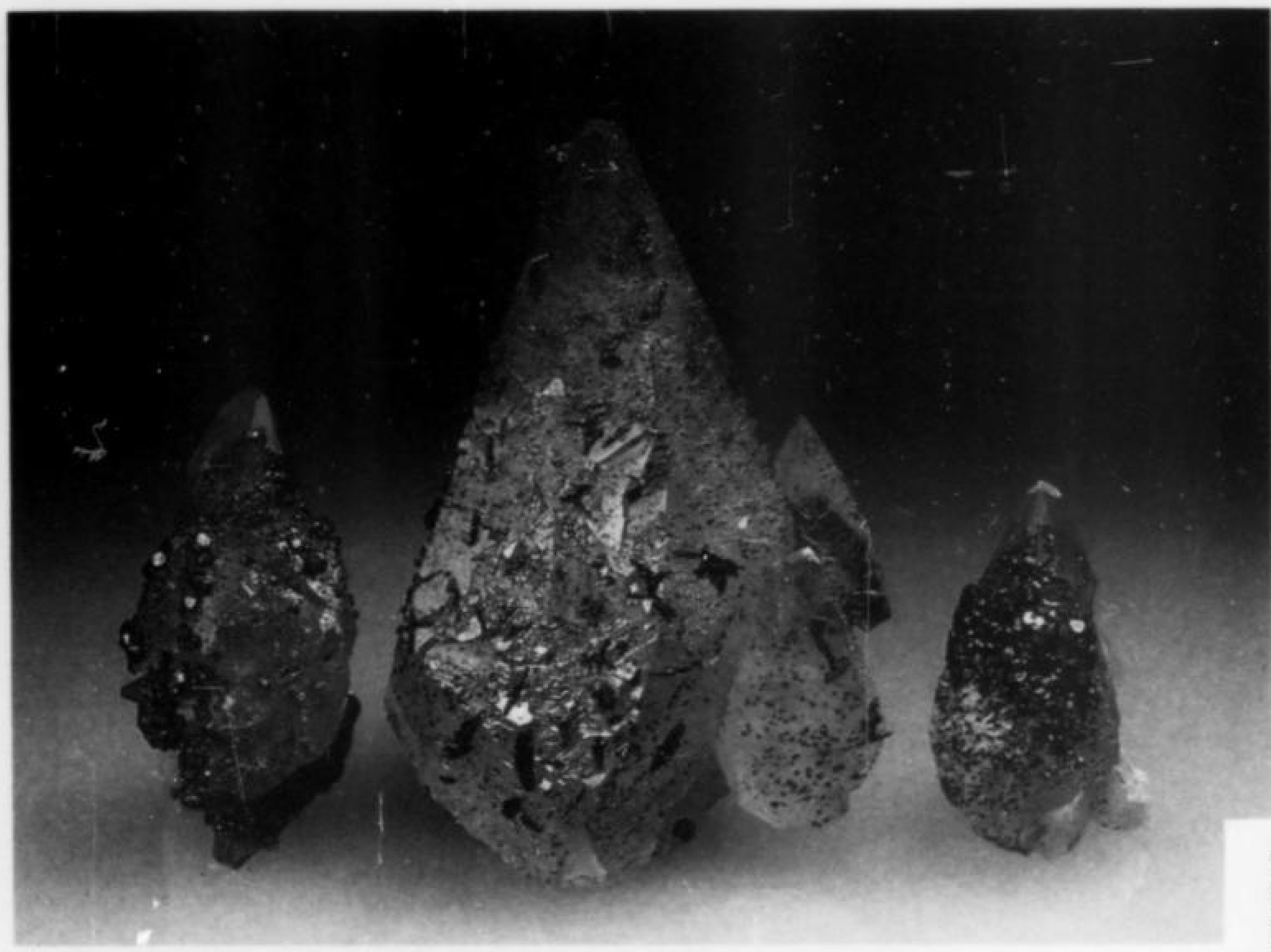

Figure 6. Colorless scalenohedral calcite crystals to 4.4 cm, with pyrite and marcasite, from Pint's quarry. Janet Schmitt collection.

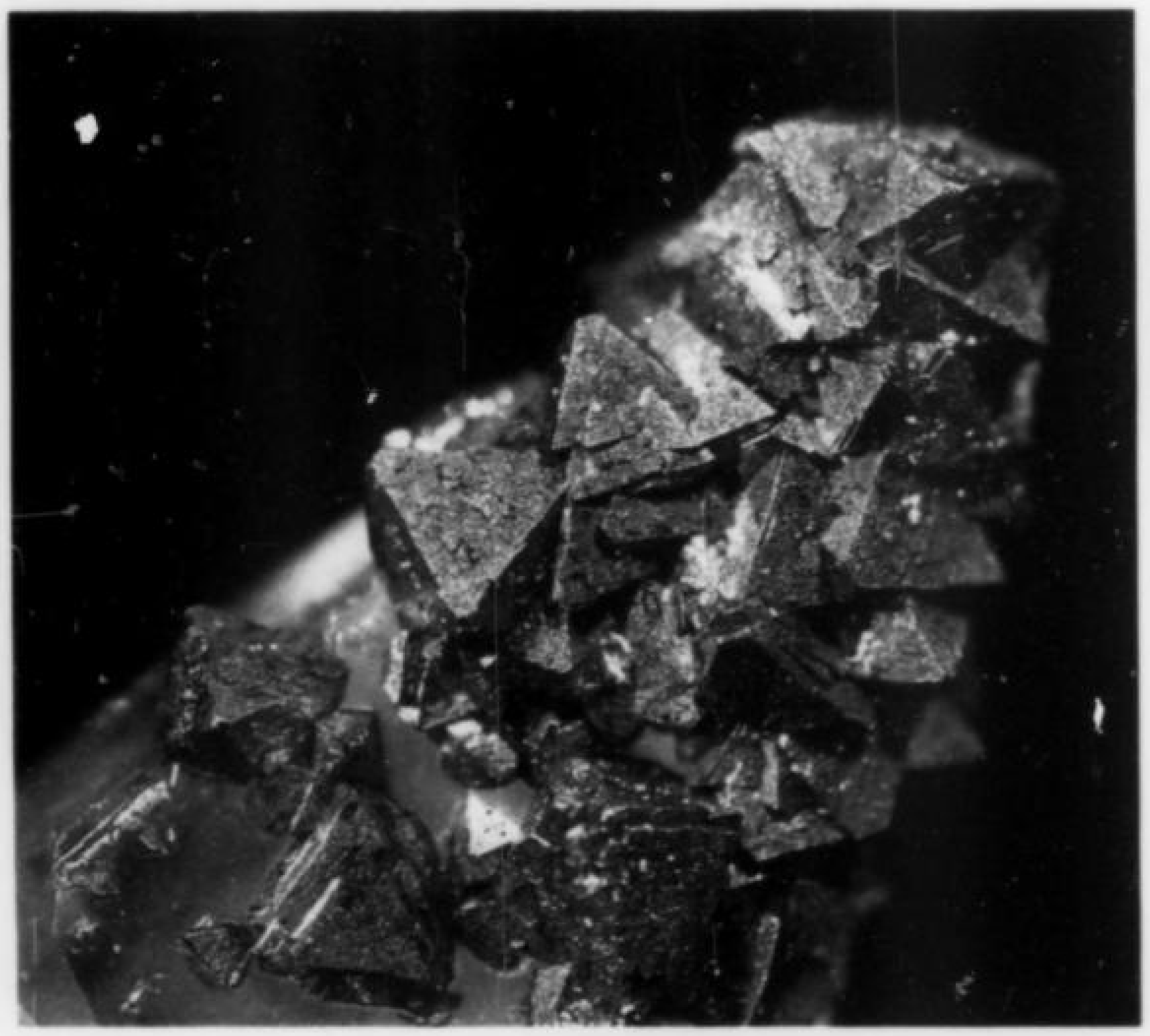

Figure 7. Octahedral pyrite crystals on a calcite crystal, 4.7 mm, from Pint's quarry. Dan Behnke specimen and photo.

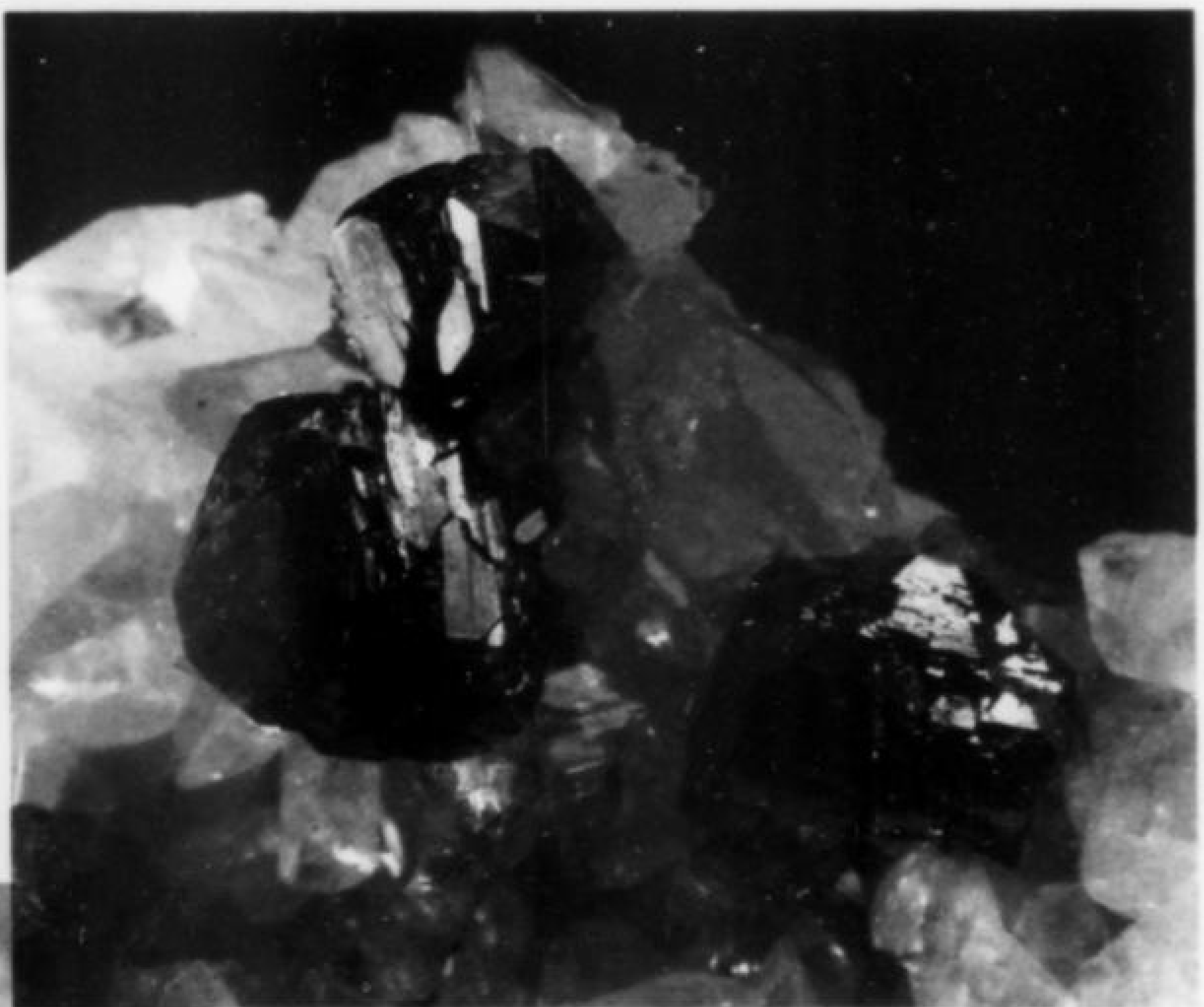

Figure 8. Pyrite crystals with irridescent tarnish, from Pint's quarry. Janet Schmitt collection.

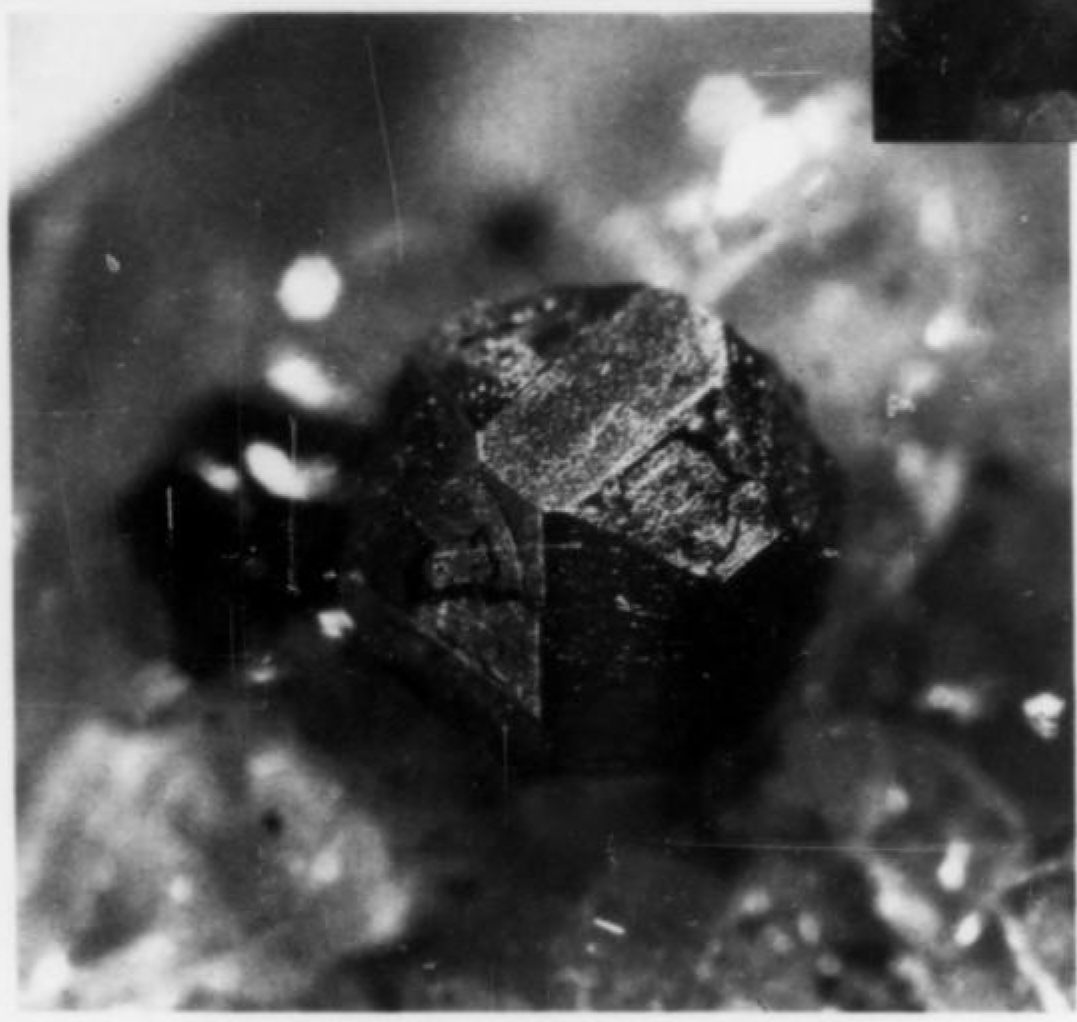

Figure 9. Pyrite crystal, 2 mm, showing about equal development of cube, octahedron and pyritohedron faces. Dan Behnke specimen and photo.

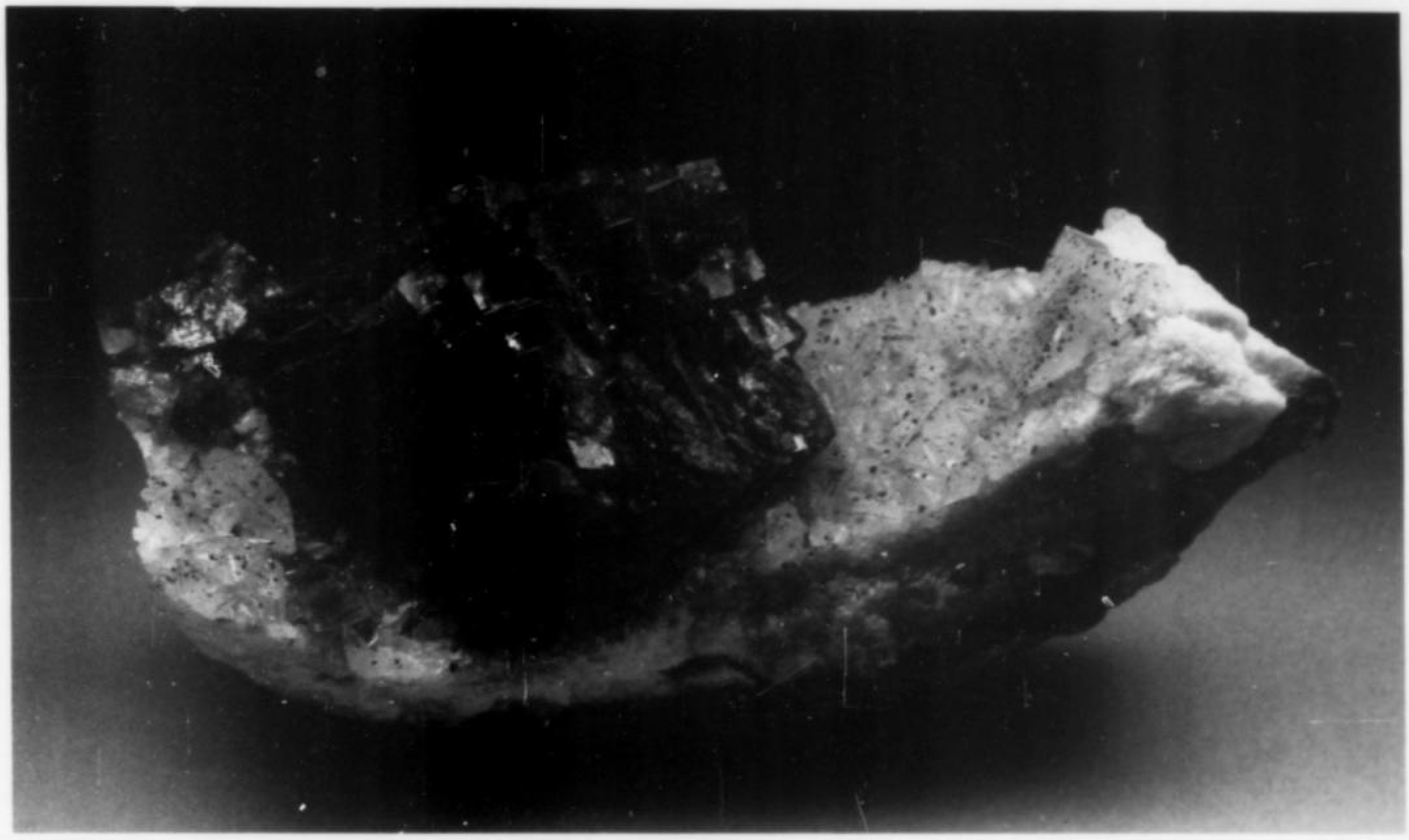

Figure 10. A large, composite fluorite crystal, 4.6 cm, on matrix. David Malm collection.

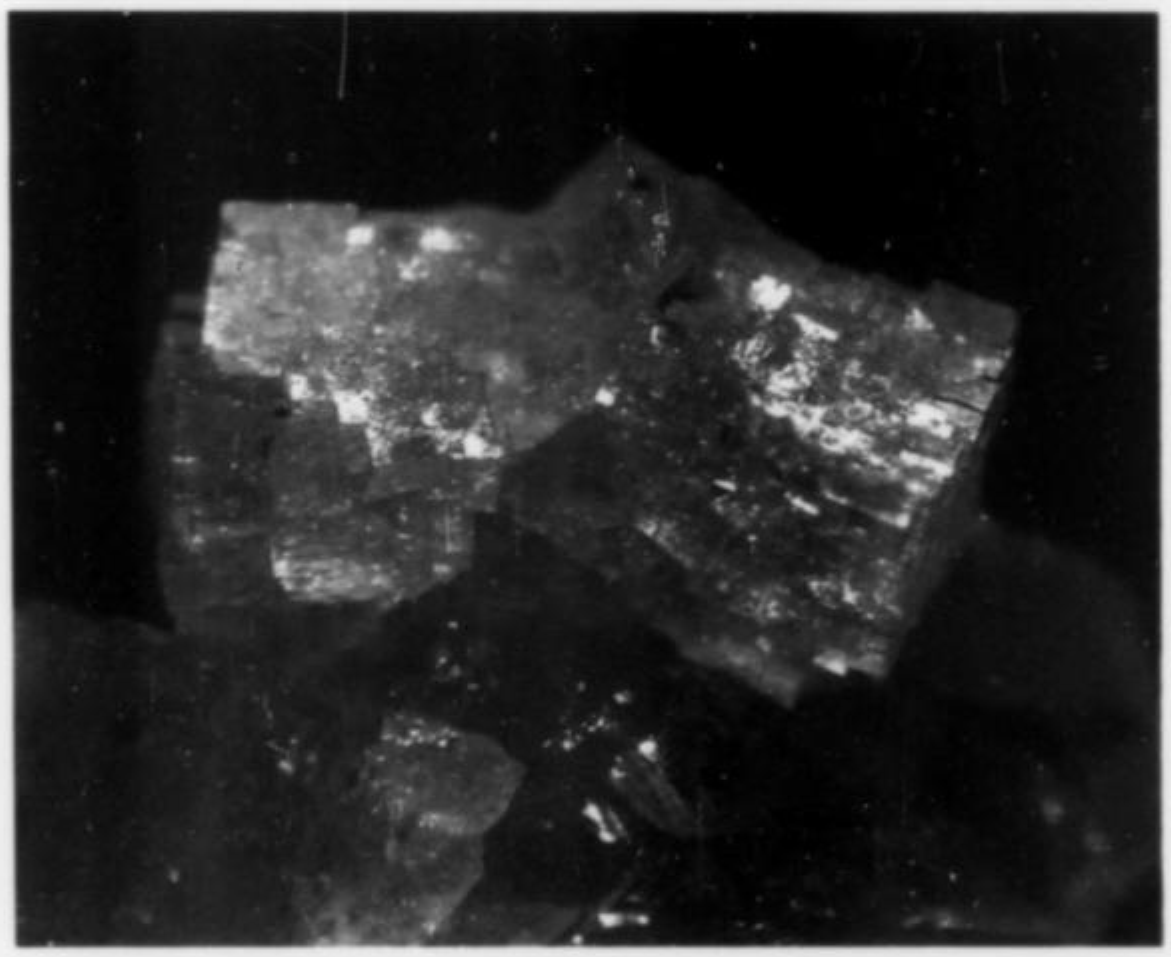

Figure 11. Intergrown fluorite crystal group, 4.5 mm, on calcite from Pint's quarry. Dan Behnke specimen and photo.

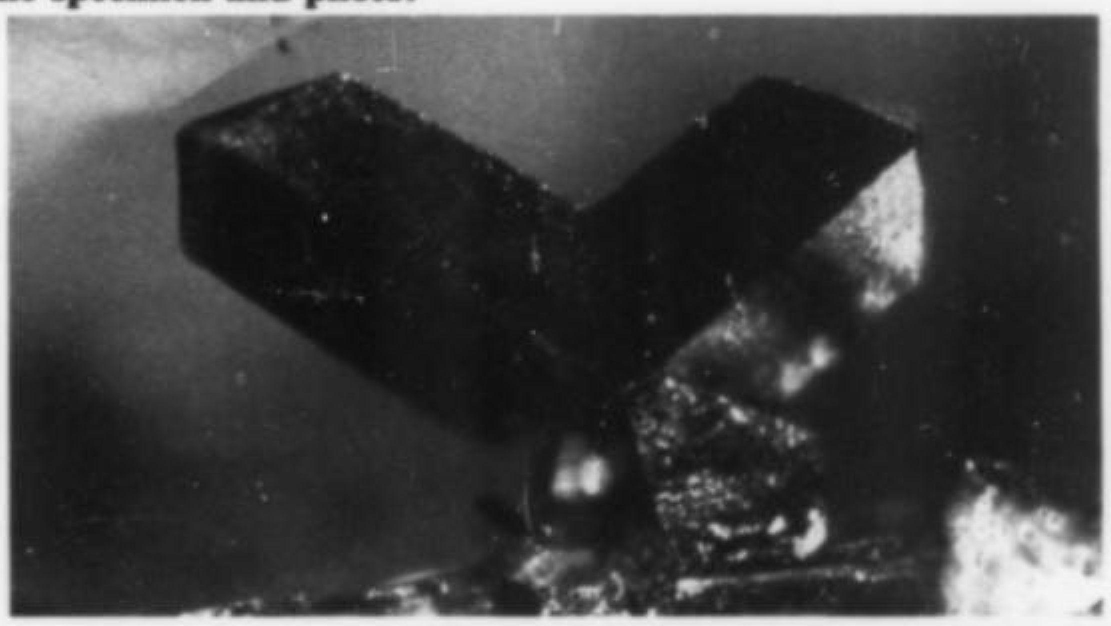

Figure 13. Marcasite twin, about 1 mm, from Pint's quarry. Dan Behnke specimen and photo.

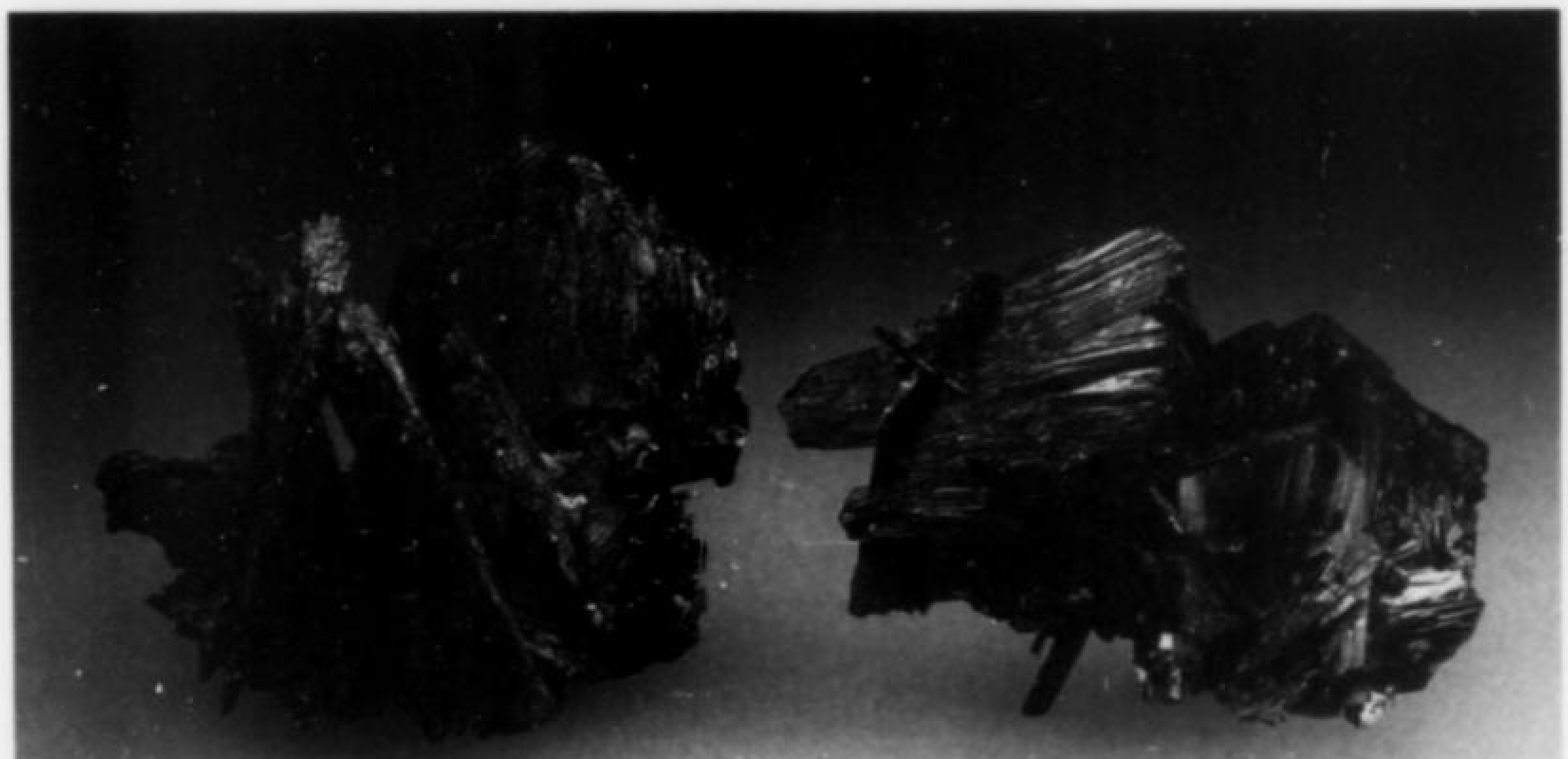

Figure 12. Marcasite crystal groups to 3.2 cm, with colored tarnish. David Malm collection.

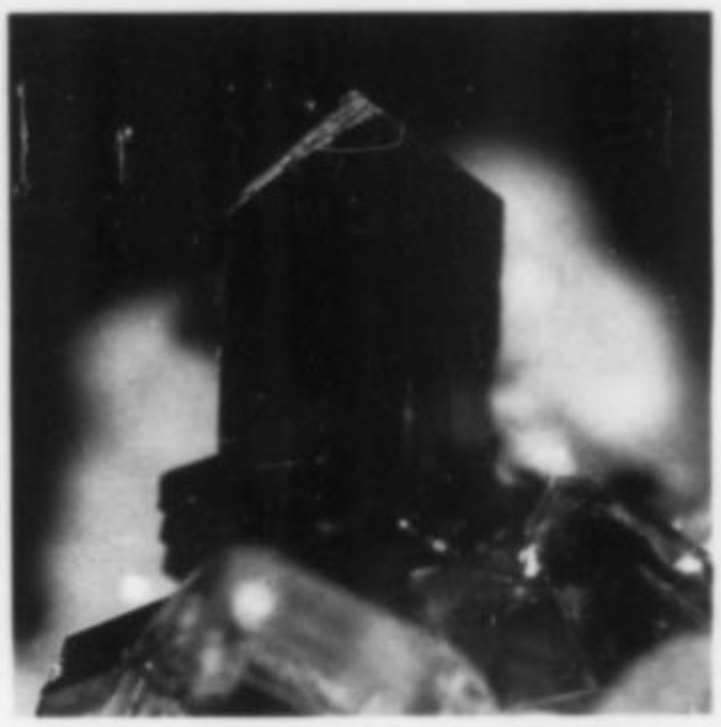

Figure 14. Marcasite crystal, about 1 mm, on calcite, from Pint's quarry. Dan Behnke specimen and photo.

The curved forms have rhombohedron and a combination of scalenohedron and rhombohedron faces. The origin of the curved faces is unclear. X-ray powder studies do not reveal systematic absences or displacements of reflecting planes which might indicate strain during growth. Some of the curved surfaces are etched, dulled and stepped, and may have formed by dissolution rather than crystal growth (Dickinson and De Nault, 1981).

Fluorite CaF_2

While purple fluorite druses can be found rarely in the Rapid Member, Pint's quarry is most noted for the rich honey-brown fluorite crystals that occur primarily in the Solon Member. Fluorite is found in cubic crystals, both singly and in complex intergrowths. Individual crystals can range in size up to at least 6 cm with connected groups attaining much larger sizes.

The average fluorite crystals are much smaller. These pale amber-colored fluorites in the 2-mm range can commonly be found covering large areas of a vug and are often dotted in turn with tiny pyrite crystals. This kind of fluorite is generally part of an obvious sequence of mineralization which begins with calcite, followed in turn by pyrite, fluorite and pyrite again. Fluorite crystals in the 1-cm range are not rare, and like their smaller and larger cousins have good color and a nice bright luster.

According to Garvin (1984), all fluorite from Pint's quarry fluoresces creamy white to whitish yellow in longwave ultraviolet light.

Galena PbS

Galena is extremely rare. Menzel and Pratt (1968) reported a single occurrence, while Lin (1978) located two specimens containing galena in local collections. X-ray diffraction procedures confirmed the identity of galena in one of these cases. Garvin (1984) reported a single occurrence of massive galena, thinly coating a fracture.

Gypsum $CaSO_4 \cdot H_2O$

Gypsum at Pint's quarry is also very rare. It was found by Garvin (1984) at a single site. The gypsum is massive and intimately intergrown with calcite, suggesting a replacement origin.

Marcasite FeS_2

Marcasite is quite common and can be found at most levels in the workings. Generally it is found in blades, but needles and equant tabular forms also occur. Single and polysynthetic twins are known.

Blades up to a centimeter in length are present in some abundance, but a recent find of intergrown crystals in floater groups has included individual crystals up to 3 cm long by a centimeter wide by a millimeter or two thick. Tabular marcasite crystals are considerably smaller, but are sometimes arranged in clusters and groups of highly irridescent plates that are attractive. Marcasite blades, plates and needles (often mistaken for millerite) are common inclusions in the larger calcite crystals at Pint's.

In the Solon Member, marcasite is much less common than pyrite, but the situation reverses in the Coralville Member. Vugs in the latter very often contain only calcite crystals sprinkled with small blades and needles of marcasite. Pint's quarry marcasite appears to be stable in all of its forms.

Pyrite FeS_2

After calcite, pyrite is the most common crystallized mineral in the quarry. The octahedral form predominates, but cubic crystals can be found. The pyritohedron form is subordinate and is known only in combination with the other two forms. Crystals are routinely intergrown, sometimes into nodular masses and crusts.

The pyrite occurs in bright brassy crystals and also with multicolored irridescent coatings. In either case the crystals are sharp and highly reflective. Octahedrons that approach a centimeter on a side have been collected, but are unusual. On the other hand, crystals in the 3–4 mm range are quite common, and by virtue of their abundance on a piece, can be very attractive. In fact, it is the varying distribution of pyrite crystals that makes the material from Pint's interesting. From single crystals perched on the tips of calcites to solid intergrown masses, every intermediate level of coverage is present.

Quartz SiO_2

Quartz is most commonly observed as a replacement of corals in the Solon Member. Far less frequently it can be found in clusters of well-terminated crystals up to a centimeter in length.

Sphalerite ZnS

Sphalerite, while rare, occurs much more often than galena at Pint's quarry. When found, it is usually in the form of a single dark brown, almost black, tetrahedron less than a centimeter in size. According to Lin (1978), the dark color probably indicates high iron content.

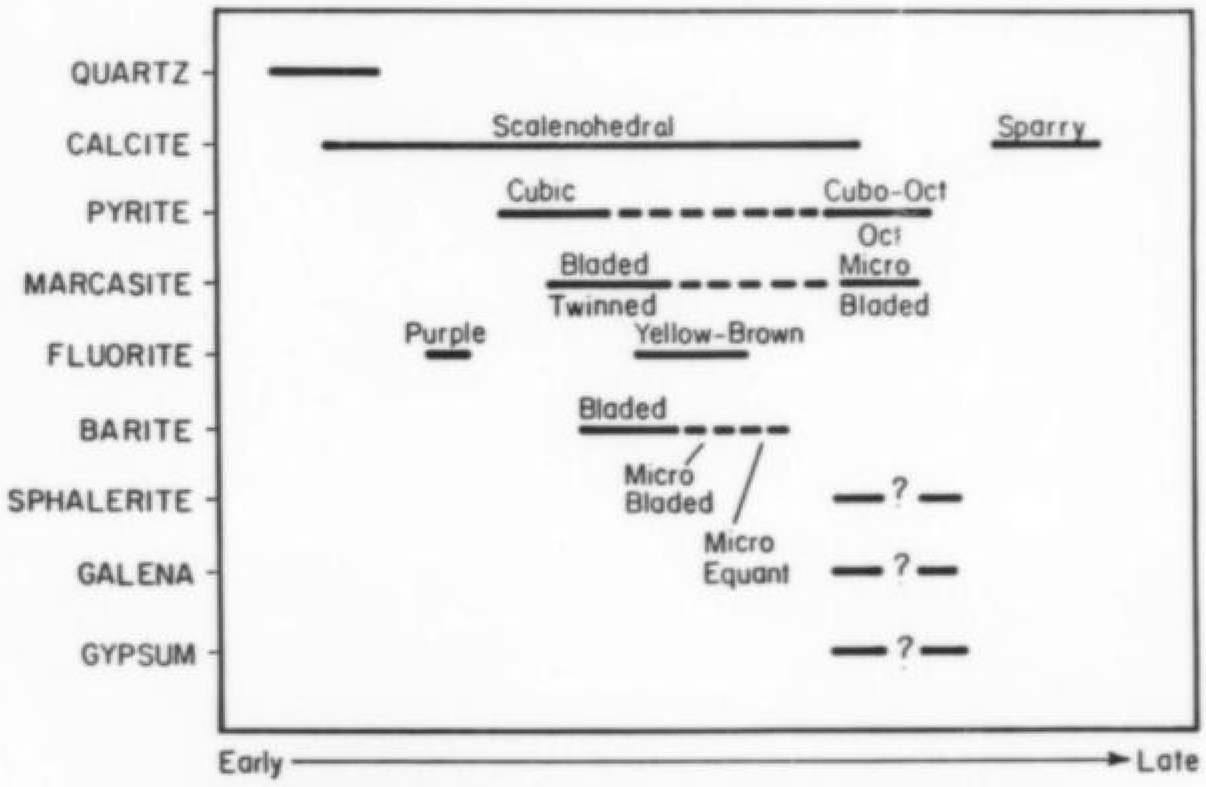

Figure 15. **Paragenetic sequence of mineralization at Pint's quarry (Garvin, 1984).**

CONCLUSIONS

Pint's quarry is a major source of well-crystallized brown fluorite, but should also be recognized for the attractive assemblages of other minerals found there.

Pint's quarry owners have, over the years, taken a very enlightened attitude toward collectors. It is the authors' heartfelt hope that the publication of this article does nothing to endanger that status. Permission to collect *must* be obtained from the operator, Basic Materials Corporation, Post Office Box 2277, Waterloo, Iowa 50704. Only organized groups are admitted. The quarry is routinely patrolled by the Black Hawk County Sheriff, and collecting without permission can result in arrest. Impeccable collecting manners, appropriate equipment and respect for quarrying operations are essential. Collecting success varies from poor to very good depending entirely on recent operations, and the one-time visitor can easily be disappointed.

ACKNOWLEDGMENTS

Our thanks to Dan Behnke and Wendell Wilson for providing the specimen photography.

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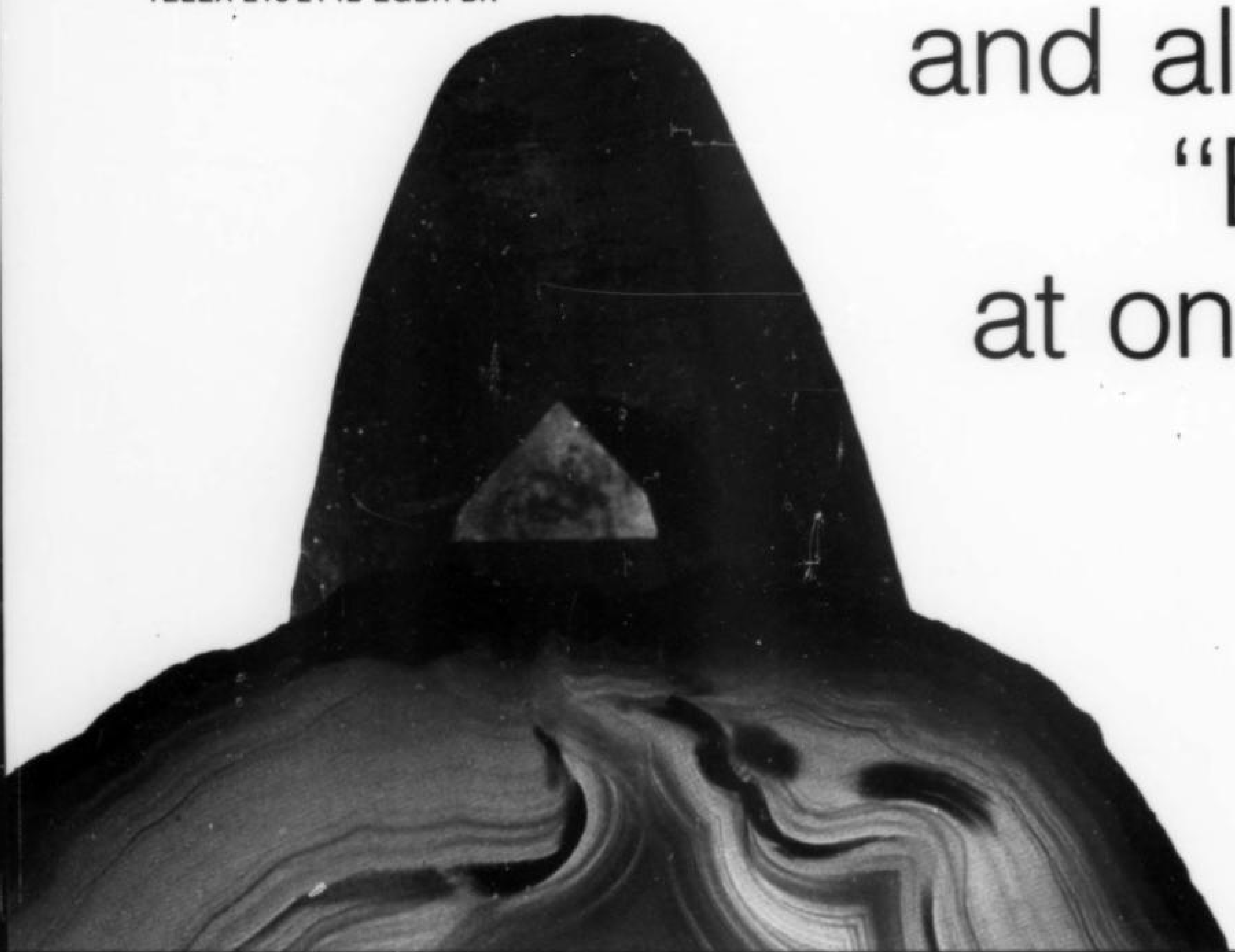

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What's New in Minerals?

Springfield Show 1989

The second annual Springfield, Massachusetts, show was held August 11–13, 1989. Formally known as the "East Coast Gem, Mineral & Fossil Show," it drew a respectable attendance of 5,000 in 1988, and nearly 5200 this year. It boasts a good selection of mineral dealers and, what's equally important, *good air-conditioning* in the Springfield Civic Center. This show could well become the most popular and prominent mineral event in the Atlantic states, if it isn't already.

There were some new things to see in minerals at Springfield, the most significant of which were Victor Yount's rhodonite specimens from the Chiurucu mine near Huanzala, Peru. The crystal groups consist of individual, terminated, thick-bladed crystals to 5 or 6 cm in length and 1.5 to 2 cm across, rather closely packed. The color is a brilliant, deep pink that is very attractive; the luster is bright, and the crystals are pleasantly translucent. If it weren't for the gemmy rhodonite from Broken Hill, Australia, these new Peruvian pieces would probably be considered the world's finest for the species. Yount had four specimens in the miniature/small cabinet size range and two fine cabinet specimens, the pick of a 100-specimen original lot. Dennis Belsher (*Worldwide Resources*) got much of the rest.

D. J. (Doug) Parsons had some excellent realgar groups from Shimen, Hunan province, China. By coincidence some of these are very similar in habit to the Peruvian rhodonites: flat, terminated, bladed crystals to over 3 cm, some of them rather gemmy, in miniature and cabinet-size groups. A few of the larger pieces have white scalenohedral calcite crystals as a matrix, with yellow pararealgar or orpiment.

Miriam and Julius Zweibel (*Mineral Kingdom*) had several interesting things from southern Africa. These included some new cuprite on chrysocolla, said by their supplier to be from the Mupine mine, Shaba province, Zaire (where the beautiful cobaltian calcite of recent years originated), and not from the Mashamba West or Dikuluwe mines which have yielded identical material in the past. They also had some rare specimens from the Kombat mine in Namibia: malachite pseudomorphs after azurite; gemmy cerussite twins; a blocky, very dark yellow anglesite crystal; and a cabinet specimen of drusy mimetite. Although the Tsumeb and Kombat mines are relatively close together and are operated by the same company (Consolidated Gold Fields), management at the Kombat mine has been more energetic in preventing mineral specimen removal by miners, and as a consequence Kombat mine specimens are comparatively rare. The Kombat mine has yielded nothing at all lately, due to a disastrous underground flood a year ago (see vol. 20, no. 2, p. 161). However, the mine is gradually being pumped out and reclaimed; it may be only a matter of months before production is again underway.

In the "buyer beware" category, a dealer knowledgeable in African minerals reported that some dealers in Namibia have been purchasing cubic zirconia, the synthetic diamond substitute, and are having it cut into octahedrons which they mix in with parcels of uncut octahedral diamond crystals. My guess is these parcels are then sold illicitly to visiting foreigners; legal channels are probably too tightly controlled to permit such fraud.

Joe Kielbaso (*Gemini Minerals*, P.O. Box 52, Tipp City, OH 45371) had an extraordinary galena specimen from the Sweetwater mine, Reynolds County, Missouri. The large, composite crystal measures roughly 20 cm on an edge; it is highly lustrous and on matrix, with white calcite crystals. This is an aesthetic specimen almost entirely free of damage. Being a lead mineral, it's also heavy: nearly 65 kg (142 pounds!) . . . not something you would want to put on the top shelf of your mineral cabinet.

Next year's show is planned for August 10–12 (1990). Contact Ron Bentley (6 Claremont Street, Enfield, CT 06082) for more information. The "show motel" is the Holiday Inn Springfield, just eight blocks from the Civic Center, but there is no satellite show. W.E.W.

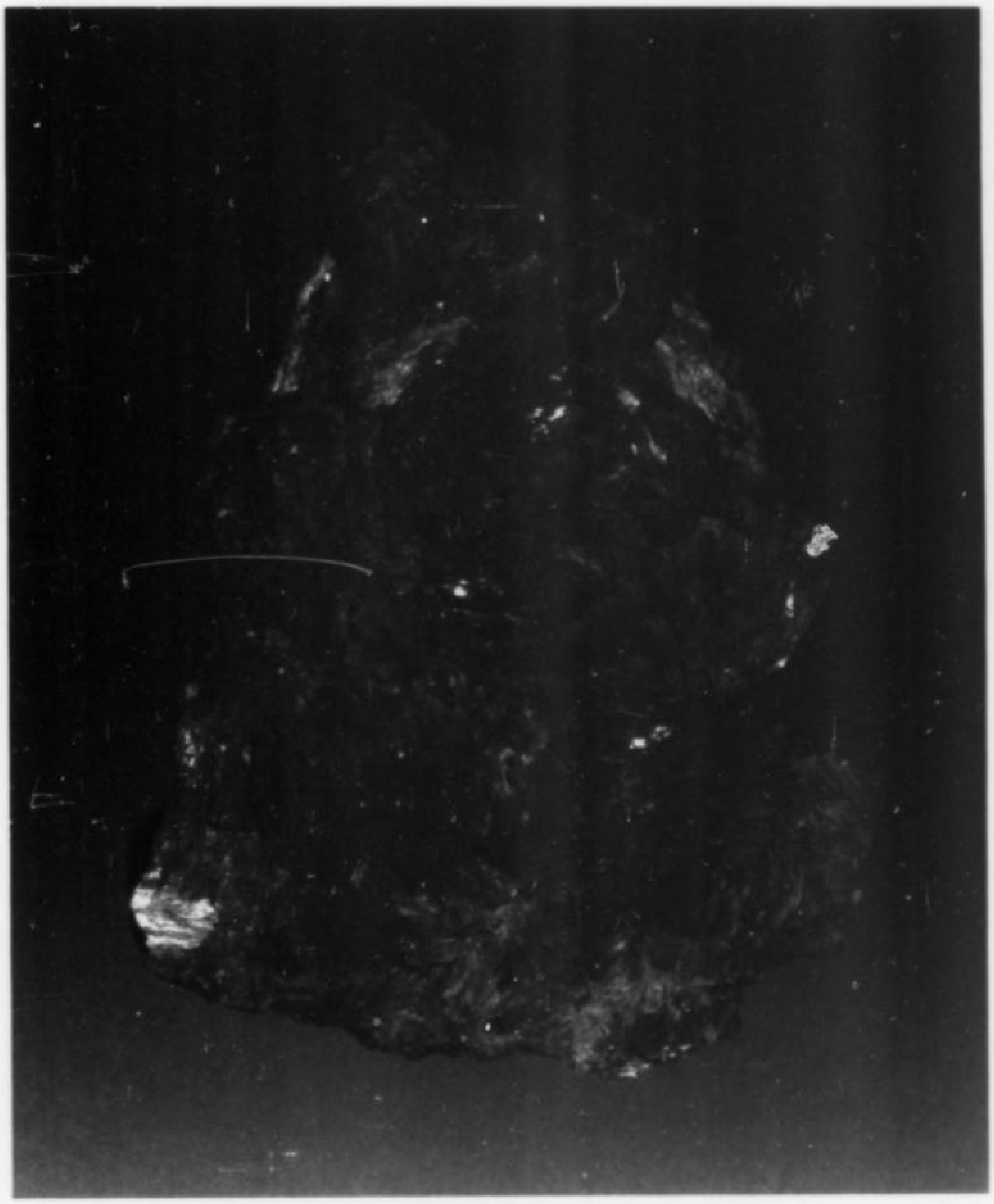


Figure 1. **Rhodonite group, 15 cm, from the Chiurucu mine near Huanzala, Peru. Victor Yount specimen.**

Notes from

Europe

by **Thomas Moore**

Bad Ems, Ste.-Marie, and Rheinland-Pfalz Shows 1989

For much the greater part of the time during the spring and early summer mineral show season, warmth, clear skies and low humidity prevailed here in Western Europe. Joggers, Volks-marchers, tennis players and field collectors of course responded in appropriate ways. Even the U.S. dollar, following the temperature's lead, came up a bit, though we can't yet feel too summery-sanguine about this; today's dollar is still worth about 40% less against the Deutschmark than it was just before I began to write these Notes in 1987.

This year I attended two old standbys—Bad Ems and Ste.-Marie-aux-Mines—and one smaller show, new for me: the local Rheinland-Pfalz show in the little wine town of Deidesheim in the Rhine Valley. I have reported before on the more renowned scenes at Bad Ems and in Alsace. About Deidesheim there is culturally and touristically not too much to tell. It's a cobblestone-street and old-gabled-house town, dressed up in its quaintness in a harmlessly self-conscious way, with the flowered windowbox dowdiness characteristic of all affluent German wine towns. A typical modern hotel/cafe/exhibition hall housed the show, its parking lot carved out, as if on grudging loan, from encroaching vineyards which are the really serious business here. Thousands of parallel, undulating, flat rows of stick trellises on which the vines hang and clamber, stretch out from the town to the very end of the valley at the Rhine's marshy banks and at the base of the Pfalz foothills to the west. You've already heard similar passages from me about Bad Ems and Ste.-Marie, so let's get to the minerals.

Of the three shows, only Bad Ems had a special display, in a wallfull of glass cases on the gallery above the main floor, happily presided over by show chairman Rainer Bode. The display's general title was "Schätze aus den Hohen Tauern," although, in fact, not only Treasures From The Hohe Tauern Mountains (Austria) but also many fine things from the Siegerland region of Germany were to be seen. These latter were brought by the University of Bonn and by collector Gerhard Schweisfurth of Siegen. It's only because I wrote at some length about a larger such Siegerland array in the 1987 Munich report that I refrain from discussing individual pieces here. The Austrian Alpine section of the display, for which both Alois Steiner of the Heimatmuseum, Bramberg, Austria, and Dr. Gerhard Niedermayr of the Vienna Natural History Museum were responsible, featured such wondrous highlights as an enormous schist matrix studded with sharp, deep green Habachtal (Pinzgau) emeralds to 6 cm long; a magnificent 20-cm Knappenwand epidote; orange, twinned titanites to 4 cm on a 15-cm matrix from Habachtal; the world's best bornite crystal, a 4 x 4-cm trapezohedron (pictured in Burchard and Bode's *Mineral Museums of Europe*, p. 194) from the Frossnitzalpe; from the same place, a loose, complete, root beer-brown brookite floater 6 cm long; and pink fluorites, hematite "roses," giant scheelites, even larger giant andularia and quartz groups.

Even the best of the Alpine pieces on exhibit almost found their peer in the specimen displayed down in the main lobby by ace dealer *Helmut Brückner:* a Brazilian pegmatite boulder about a meter in size, covered with little purple lepidolite books and large albite rosettes, with, centered on top and standing straight up, a 10 x 11-cm, gemmy blue, shiny, transparent topaz with clean chisel termination and no visible damage. I stared at this almost as long as I did at Brückner's other, subtler, show-stopper: a 5 x 6-cm group of brilliant, stacked argentite octahedrons from Freiberg, with an old Fred Cassirer label.

Elsewhere at the Bad Ems show there was the usual respectable showing of old German classics. For example, *Helmut Bolland* (Gartenfeld 27, D-5632 Wermelskirchen 2) was offering fair to good cabinet specimens, most with old labels, of typical minerals from the Grube Clara, Schwarzwald; Wölsendorf, Bavaria; Bad Ems; the Siegerland; the Eifel; Erzgebirge silvers, proustites and stephanites; and, from the Golden Triangle area of Rumania, hand-sized matrix specimens with visible crystals of gold in seams, as well as krennerite, nagyagite and other tellurides. From other dealers—most notably *Mineralien A. & R. Fricke* (In der Aue 57a, D-5860 Iserlohn) and *Siegbert Zecha* (Windecker Pfad 1, D-6369 Schöneck 2)—there were such Dana venerables as bournonite on white barite from Ramsbeck; Siegerland millerite and chalcopyrite; microcrystals of cinnabar on glassy barite from Rieschberg/Baumholder; a few thumbnails of cyclically twinned, frosty white cerussite from Bad Ems; arborescent copper of excellent form from the Grube Wolf, Herdorf, Siegerland (only $30 for a thumbnail). There was a surprising plenitude around the show of brown Bad Ems pyromorphites: good sparkly tan pieces of 7 to 10 cm with crystals to 1 cm could be had at several dealers' stands for an average of $150, although as in earlier years the green pyromorphites were much scarcer and more expensive. Many of these old German things were one-of-a-kind, but some came in modest swarms of mostly cabinet-sized specimens. No single one was a museum-caliber knockout, but all taken *en masse* were most impressive for a single medium-sized show. Hardly any comparable old material was to be seen this year at Deidesheim or even at Ste.-Marie . . . though here I did, come to think of it, spot a few good thumbnails of the excellent bournonite that occasionally trickles out of the Mine de la Mure in Isere, France. These are medium-bright cogwheel groupings on sparkling drusy quartz matrix with minor siderite; they could be had, in their homeland, for a reasonable enough $60 to $100.

At Siegbert Zecha's stand were a few mostly thumbnail specimens of a remarkable new anatase from Norway, not to be confused with the older "Hardangervidda" or "Matskorhae" anatase—pointed blue-black bipyramids to 1 cm at most, these older ones, scattered on sometimes immense quartz crystal groups (see vol. 8, no. 4). The new crystals feature, by contrast, flat basal terminations on the bipyramids; the matrix where present is drusy albite; and, though as dark-looking at first glance as the older crystals, these are not really blue but red, with richly glinting rubous highlights. Most often the crystals come as loose singles to 2.5 cm long, but sometimes they form parallel groupings which are extremely bright and handsome. The best matrix-free thumbnails of this sort cost around $200. Apparently the largest crystal yet found, now in the Kongsberg Mining Museum, is 4.8 cm long—see its picture on p. 238 of vol. 20, no. 3. The locality is (no surprise) very vague. "Valdres region" appears on some labels, and the big one (mentioned above) displayed by the Kongsberg museum at the recent Tucson show is labeled as coming from "near Gudbransdalen." My atlas tells me that Gudbransdalen and Valdres are names of mountainous areas of considerable extent in central Norway, Valdres being about 160 km northwest of Oslo,

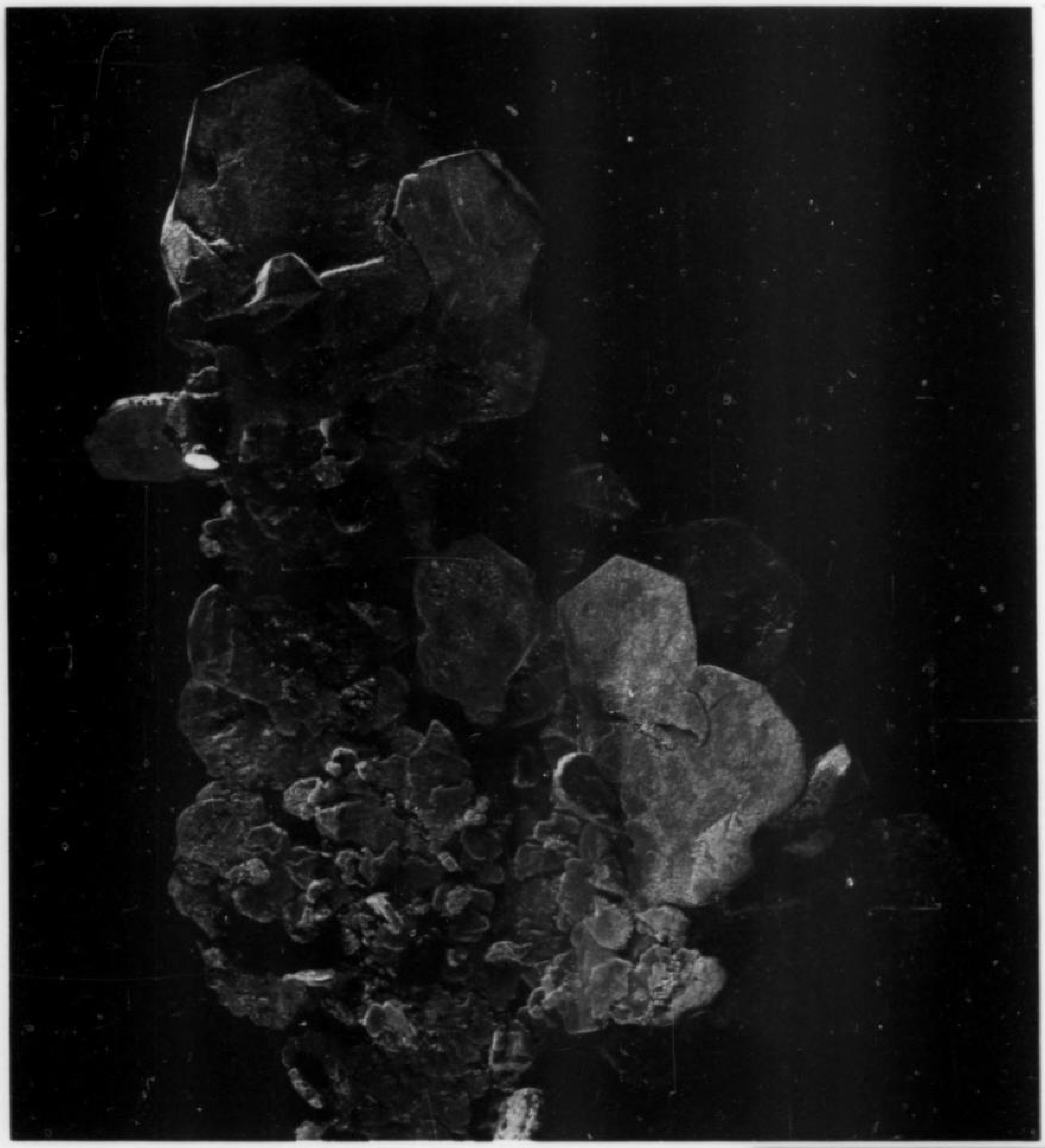
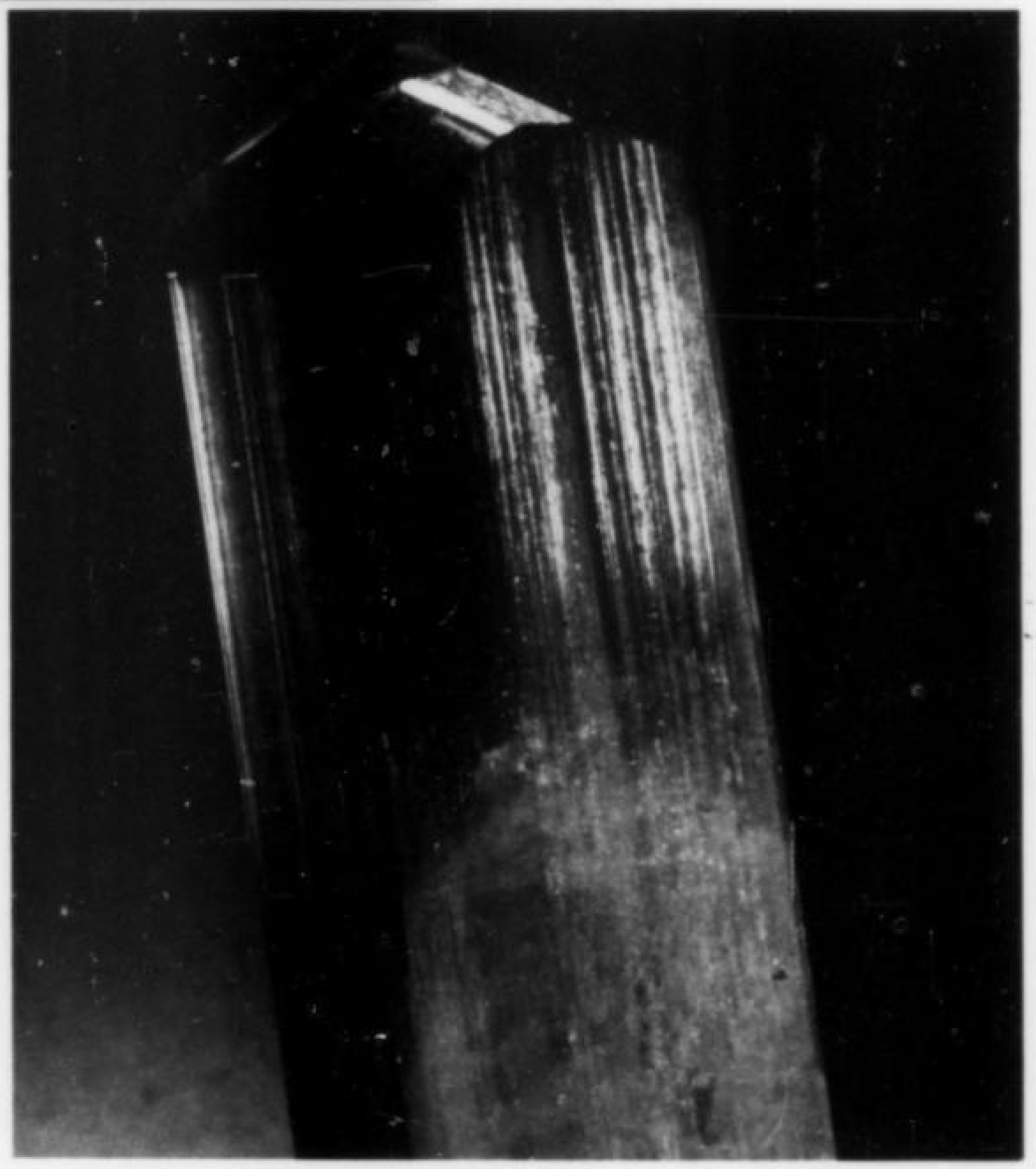


Figure 1. **Malachite-coated copper crystal group, 3.5 cm tall, from Grube Wolf at Herdorf, Siegerland. Werner Lieber photo.**

Figure 2. **Diaspore crystal, 2 cm, from the Aydin Mugla region of western Turkey; this is the same crystal that was sketched in this column in vol. 18, no. 2. Werner Lieber photo.**



and Gudbransdalen some 80 km yet farther north. One hopes, of course, for more of these world-class anatase specimens, but the rumor is that no more are to be found and that the original finder is now slowly releasing his hoard onto the market. So they would seem to be very good buys at whatever U.S. show they may stray into . . . I saw none further at Deidesheim or Ste.-Marie.

Of what else is new in contemporary material, well, at Bad Ems I saw for the first time the beautiful blue cavansites from Poona, India, recently brought out by dealer Hans-Jürgen Wilke and fully described in a recent issue of *Lapis;* I hoped to break the news of them here but Wendell Wilson scooped me in his Tucson show report (vol. 30, no. 3). So far the cavansites are plentiful here in Europe, though certainly not cheaply to be had from any of the half dozen or so dealers who have been offering them: a small thumbnail, typically a loose spray 1.5 cm or so across, is apt to cost something like $70, and matrix miniatures and small cabinet pieces, with sprays sparsely scattered around on stilbite crystals on traprock, can run up to $400. And the sprays themselves, whether loose or on matrix, are too often bashed. The very best specimens I've seen yet—at Ste.-Marie—show cavansite in parallel groups of flat crystals (see Fig. 1 in Wilson's report) to 2 cm, nicely perched on or snuggled in crannies of snowy white stilbite.

Meanwhile I do have a new and exciting occurrence to scoop after all. My awareness of it began at the Deidesheim show. There I spied, lurking by a cluttered table off in the corner, a furtive-looking Afghan rock-hawker who needed a shave, and *on* the cluttered table some

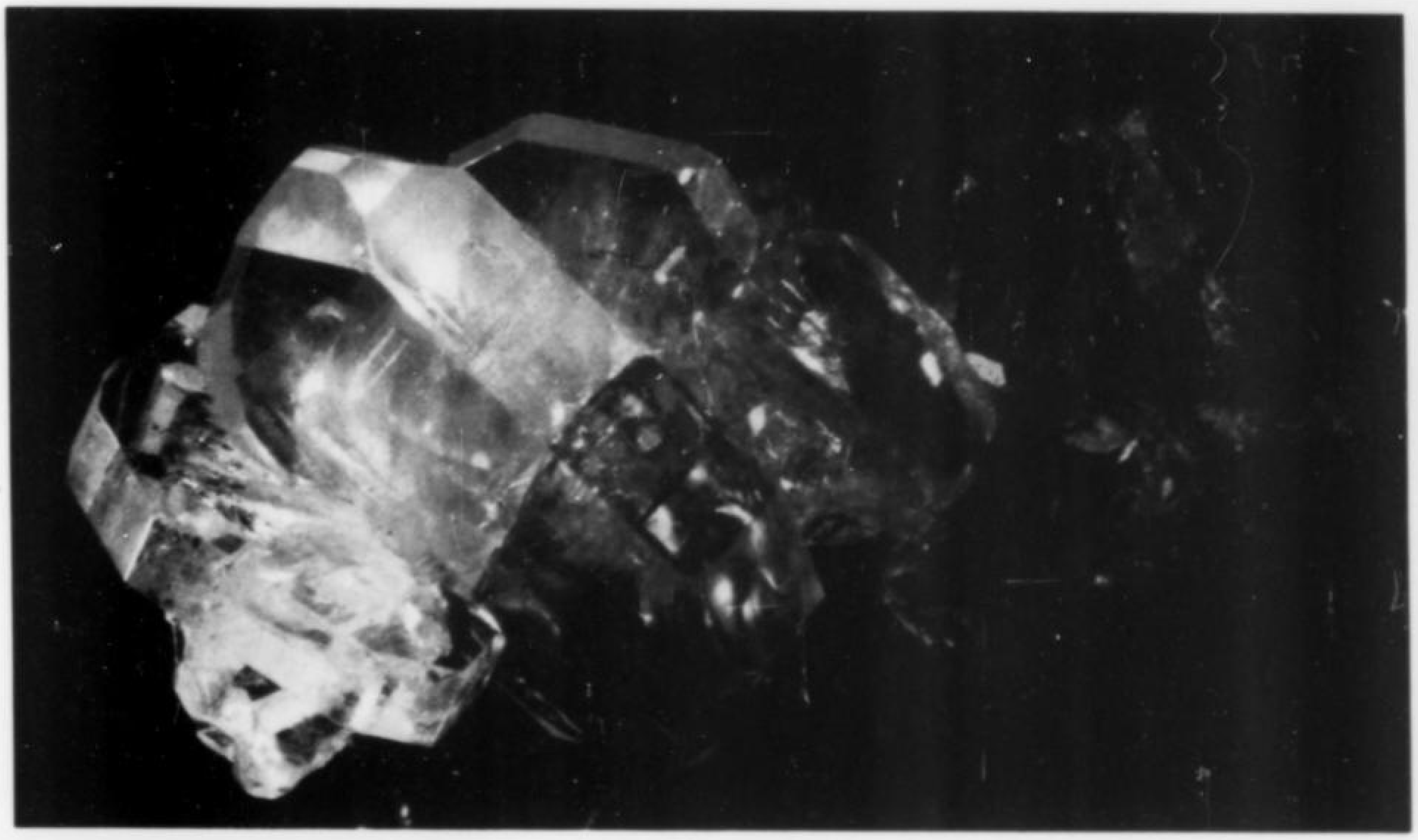


Figure 3. **Barite crystal cluster, 2.5 cm across and colorless, from Stanislawow, Silesia, Poland. Werner Lieber photo.**

Figure 4. **Cavansite crystal spray, about 1.5 cm across, with stilbite from Poona, India. Werner Lieber photo.**

beautiful garnets of a kind I hadn't seen anywhere else before. The crystals are simple dodecahedrons, brightly glassy and shiny, dark *green* to almost black in color, yet with surprisingly reddish highlights in some smaller crystals. All specimens are very classy looking, and come either as large (to 4 cm) singles and loose clusters, or matrix pieces. The matrix is interesting and attractive, consisting of a phyllitic rock blanketed by glassy, pale green diopside crystals to 3 mm and darker green epidotes of the same size, mixed occasionally with areas of micro-sized magnetite. These make extremely handsome specimens with the large garnets (tentatively identified as grossular by the dealers) studded on them, and the locality is of course the major enigma. The Afghani said that they came from Jalalabad Province, Afghanistan; from a German dealer who ought to know I hear that the source is Saedu Sharif, Pakistan; from an equally credible French dealer I hear that it's Tang e Achine, Pakhtia, Afghanistan. These sites are probably quite close together along the two countries' border, and may be no more than small prospects; what with the political instability in these parts, it's easy to see how confusion could result. But garnet fanciers take note: these are remarkably attractive pieces. And more: in their vicinity at several dealers' stands, beginning with the furtive Afghan's, could be seen modest numbers of the new, sharp, often gemmy, rich yellow-green fishtail titanite twins generally said to come from Haramosh, Pakistan. The best of these are easily the equals of the classic Austrian and Swiss titanites that they resemble, and occasional associations of chlorite-dusted adularia crystals confirm that the Alpine-cleft mode of occurrence is the same.

The Ste.-Marie show was quite strong, as in earlier years, in Spanish (and Panasqueira, Portugal) material, although I regret to report that prices are rapidly escalating—skyrocketing, chain-reacting—on the wonderful colorless bladed gypsum crystals in alabaster solution cavities from Fuentes de Ebro, near Zaragoza (see vol. 20, no. 2, p. 143). As recently as a year ago at Ste.-Marie one could buy a lovely miniature of those for as little as $15, but now for the same miniature one must pay around $40 to any of the considerable number of dealers who have them. Counterbalancing good news, however, is to be found in the rapidly increasing availability of excellent Russian specimens. For example, F. Lietard of *Minerive* had just completed an exchange with a Soviet collector and was offering astonishing pyrrhotite rosettes to 12 cm across on quartz matrix from Dal'negorsk on the Soviet Pacific coast, huge Russian purple creedites, amazonites, and green fluorites, and a small slew of the more familiar etched heliodor beryl prisms from Volodarsk, Ukraine. Also getting ever more common around Europe are the fine vivianite fan groups on earthy brown limonite geode matrixes from Kertsch, Crimea: these sea-green to smoke-blue fans sometimes make almost complete spheres to 3 cm across, and a top miniature can be had for about $80. Bright emerald-green, thin druses of 1-mm uvarovite crystals over chromite from Sineretchenskoye, Urals, may also occasionally be sighted.

At the two larger shows there was an abundance of the new octahedral cuprites, associated with chrysocolla, malachite, and white barite, from the Mashamba mine, Zaire. The good news here is that the octahedral form is sharp, the color a gorgeous red, and the associations interesting. At Bad Ems I saw cuprites to 2.5 cm deeply embedded in, and sometimes completely covered by, a soft sky-blue chrysocolla blanket, and also sharp pseudomorphs of the same chrysocolla after subparallel and fan groups of the barite, with interlayerings of acicular malachite, and small sparkly red second-generation cuprites on top. Some specimens have a black metallic matrix. The bad news is that the cuprite crystals are very frequently dinged or bashed at the sides. The norm is a few bright, smooth front faces, but an unsightly chaotic red area where the rest of the crystal should be. On the very few pieces where the octahedrons are reasonably complete (one dainty thumbnail, for instance, had a sharp crystal sitting up on a velvety malachite ovoid) the price soars out of sight, though it should be added that prices generally are reasonable (as Wendell Wilson observed in vol. 20, no. 1) for such basically sterling cuprite specimens.

At Ste.-Marie the private collector Fredric Escaut of Paris, just back from Peru, was showing some fine material including one new discovery from that prolific country. The new discovery—being marketed at another stand by a dealer—was vivid rose-pink, bladed rhodonite, the blades mashed together in tight laminated masses to 20 cm high, from the Huanzala mine in Peru. The rhodonite crystals are too tightly compressed to be well individualized, but in some specimens they are slightly divergent at the top, with transparent pink terminal faces across the top edges and oddly angled subfaces to betray the species' triclinic nature. There are minor pyrite dustings on a couple of specimens but otherwise no associations; prices range from $65 for a small miniature to $250 for an 18-cm piece. At his own stand, M. Escaut had some of the best Huallapon mine rhodochrosite thumbnails I've seen in awhile, some nice cabinet pieces with small orange gypsum crystals covering quartz and sulfide matrixes, good tetrahedrites from Casapalca, and (somewhat of a cult item, icon, or fad this year at Ste.-Marie, so widespread among the dealers were these) some preposterously large groups of Peruvian pyrite octahedrons with slightly etched faces . . . I mean things a normal man couldn't lift; I am talking clusters a couple of feet across and with (modified) octahedral edges to 10 cm long. What do people *do* with such anchorlike, turgid objects, such swollen beasts, such golden fools' boulders, I wonder? (See Rock Currier's letter on these in the previous issue, p. 403.)

Finally, *Jacqueline Barbier* (7 rue Waldeck Rousseau, 38300 Bourgoin-Jallieu, France) had a few truly exquisite examples of the new Brazilian goshenite beryls, in stacked poker-chip groups impaled by green elbaite and/or lightly stained by the brown iron oxides that cement them, reported on from the Denver show (vol. 20, no. 1). These are pretty steeply priced, though not steep enough to deter me from picking up a fine thumbnail. Here also were some pretty scepter smoky quartz groups, the brown "smoke" tending to line the edges of crystal faces, with interior parts remaining milky, in thumbnail to large-cabinet sizes, from Araçuai, Minas Gerais, Brazil.

I must thank master photographer Dr. Werner Lieber of Heidelberg for the pictures shown here. The diaspore is the same crystal sketched in my 1986 Munich Show report (vol. 18, no. 2).

And speaking of Munich . . . I will do just that in due course, and hope also to speak of Zürich, along about November. Meanwhile here's hoping that your summer has proven as balmy, weatherwise and otherwise, as mine.

Thomas Moore
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FM friends of mineralogy

by **Marcelle Weber**

The *Mineralogical Record,* vol. 1, no. 1 (Spring 1970) reported that "20 amateur and professional mineralogists met in Tucson, Arizona, on February 13, 1970, to found an informal group dedicated to promoting better mineral appreciation, education and preservation. The name Friends of Mineralogy (FM) was chosen."

The November-December 1989 issue will see the completion of the *Mineralogical Record*'s 20th volume, and the Friends of Mineralogy will be 20 years old on February 13, 1990. From the beginning, the *Mineralogical Record* has been affiliated with FM, who pledged to support the magazine, since the aims of both are "similarly educational and directed toward better coordination of the interests of amateurs and professionals throughout the world."

FM's earlier years of development are documented in the *Mineralogical Record,* from the original concept of a very loosely structured organization, through Districts, to a national association with Chapters which provide smaller, more closely knit groups for greater achievement. Reports on projects, goals and accomplishments are also recorded.

There are now more than 600 members worldwide, including liaison members from the American Federation of Mineralogical Societies and from the Mineralogical Society of America. Newsletters are exchanged with The Mineralogical Society of Victoria, Melbourne, Australia.

The goals of FM as stated in the March-April 1971 issue of the *Mineralogical Record* still apply:

(1) To protect and preserve mineral specimens, especially those used for teaching, study and display, and to promote conservation of designated specimen localities and mining deposits by publicizing their historic, scientific and educational usefulness.

(2) To further a more generous spirit of cooperation and sharing of specimens and collections among mineral amateurs and professional scientists; also to encourage the collecting and acquisition of minerals for their research and educational, rather than commercial, value.

(3) To advance mineralogical education, especially in academic programs of mineral study and research, educational activities of amateur mineral organizations, and wider appreciation of mineral specimens in terms of their esthetic, scientific and economic importance.

(4) To support publications, such as the journal *Mineralogical Record* which communicates FM activities and is an educationally oriented affiliate, and those programs initiated by individuals or groups whose activities coincide with FM goals.

One of the long-term projects is the Locality Index, which has been defined and redefined. However, the locality lists of the various states which have appeared over the years in both the *Mineralogical Record* and *Rocks & Minerals* are the result of this project. Chairman is Peter Modreski, 8075 W. Fremont Drive, Littleton, CO 80123.

A major accomplishment was the *Mineralogical Record Index,* published in 1985, covering the first 14 volumes. Fourteen members, working under Mike Groben, prepared the manuscript for publication. Since that time, three members have continued to index the ensuring volumes, for future publication.

The national Vice-President annually appoints a panel of five to select the recipient of the Certificate of Award for the best article in the *Mineralogical Record*. FM contributes $200 to the *Mineralogical Record* in the name(s) of the author(s). Best article selection for 1988 was "Volcanic Zeolites and associated minerals from New South Wales" by Brian M. England and F. L. Sutherland. The award is presented on Saturday night during the Tucson Show, and it was a pleasure to have Brian England present. He also wrote "Kingsgate Mines," the best article in 1985. Only once since the project was introduced in February of 1981 (with the selection of the best article from 1980) have all five judges voted for the same article for first place: "Minerals of the Carrara Marble," by Marco Franzini, Paolo Orlandi, Giovanni Bracci and Domenico, vol. 18, no. 4 (1987).

A symposium sponsored by FM, the Tucson Gem & Mineral Society, and the Mineralogical Society of America is held during the Tucson Show. The subject for 1990 is the Show Theme Mineral, "wulfenite," and the call for papers has appeared in the *Mineralogical Record* and other publications. The Chairman is Karen Wenrich.

Another committee is considering guidelines for recognition of mining companies who make specimen collecting or acquisition possible, by whatever arrangement.

It should be no surprise that the most active membership groups under the District arrangement were the first to form a Chapter. These groups may hold regular meetings, publish or republish books of interest, organize and manage symposia, either as "stand-alone" events or in conjunction with an area mineral show.

A group of ten or more FM members in good standing can apply for a Charter. The only restrictions are that the proposed Chapter's goals and activities be compatible with the national policies and goals of FM. "How to Form an FM Chapter" is covered in the January-February 1979 issue of the *Mineralogical Record,* p. 59.

There are now six active Chapters and one inactive (Southeast Michigan).

Colorado, James F. Hurlbut, President, 2240 So. Adams, Denver, CO 80210. Dues are $10.00 per year. Their soft-bound book containing the proceedings of the *Precious Metals Deposits Symposium* is still available from FM, Colorado Chapter, c/o Jack Murphy, Geology Dept., Denver Museum of Natural History, City Park, Denver, CO 80205, $15.00 postpaid. From the same address at the same price is the book *Colorado Pegmatites*.

Great Basin, Tana Daugharthy, President, 5475 El Camino Rd., Las Vegas, NV 89118.

Indiana, Richard Eddy, President, 5235 Hartford Ave., Columbus, IN 47203. Annual dues are $15.00 and $7.00 for additional member, which includes national dues and liability insurance protection. This Chapter is in its third year. Field trips are included in the programming.

Pacific Northwest, Carl Harris, President, 7716 NE 101st Ave., Vancouver, WA 98662. A Spring Symposium was held in May.

Pennsylvania, Arnold Mogel, President, 2503 Village Road, Orwigsburg, PA 17961. Pennsylvania has published two books: *Mineralogy of Pennsylvania 1965–1975* (1978) by Dr. Robert C. Smith II, and *Historical Sketches on Copper and Lead Mining in Montgomery Co., Penn.* (1980) by Harold Evans with *Preface* and *Appendix* by Allen Heyl (1980).

Southern California, Fred DeVito, President, 1406 Norwich Ave., Thousand Oaks, CA 91360. The California Localities Index has apreared this year in the *Mineralogical Record*; $100 was contributed to the California Mining & Mineral Exhibit Association.

Membership applications may be requested of any of the Chapters, from the President or from the Treasurer, Russ Boggs, 19 3rd St., Cheney, WA 99008. If dues are paid through a Chapter, they include the national dues. To be eligible for membership, one need only believe in the goals and aims of FM.

Marcelle H. Weber, President, Friends of Mineralogy, Inc.
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Letters

ARGENTOPENTLANDITE from MICHIGAN

In September of 1986 I obtained a species collection which had been assembled over a 45-year period. It contained many old specimens requiring confirmation of species identification. These were sent to *Cannon Microprobe/SEM*, Seattle, Washington, for electron microprobe analysis using an ARL model SEMQ electron microprobe.

One specimen, which appeared to be a silver sulfide in calcite matrix, bore an old handwritten label identifying it as "Copper Arsenides [from] near Silver City, Ontonagon County, Michigan." Analysis revealed fairly abundant microscopic grains of argentopentlandite, $Ag(Fe,Ni)_8S_8$, a mineral first described as an argentian pentlandite from the Soviet Union (Shishkin *et al.*, 1971) and later raised to species status (Rudashevskii, 1977). The argentopentlandite is medium brown with a reddish tinge in reflected light. The average of three analyses yielded Ag 14.2%, Fe 35.1%, Ni 19.7%, S 30.2%, and Cu 0.2% (total 99.4%). Associations include chalcopyrite, galena, sphalerite, dolomite (?), maucherite, gersdorffite, and silver containing 4% copper.

Scott and Gasparrini (1973) reported 11 occurrences for argentopentlandite. Small grain size and intimate association with chalcopyrite are common to them all. The occurrences listed are in the Soviet Union, Finland and Canada, all in magmatic sulfides unlike the Michigan deposits, which are hydrothermal veins. The Michigan occurrence is apparently the first to be reported in the United States, assuming the locality on the old label is correct.

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Forrest Cureton
Tucson, Arizona

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In order to overcome local problems with our postal delivery, would it be possible for each issue of the *Mineralogical Record* to be marked "Please Do Not Fold" on the envelope or cover sheet?

David Hardman
Manchester, England

We used to do just that, but U.S. Postal Regulations now forbid it. Don't ask me why. Ed.

SHABA

I have in my collection ten specimens from Shaba, six of which are uranium-bearing. Five of these are from Shinkolobwe, and each has from two to five crystallized species on it. You can imagine how useful it was for me to get the July-August issue of the *Mineralogical Record*. Your photos are superior; and what a relief it is to have a fluent English text on Shaba minerals by my microscope.

It is issues like *Katanga!*, like *Tsumeb!* and *Bisbee!* and the articles on Pribram and the Tip Top mine that make the *Mineralogical Record* an outstanding tool for disentangling the species from these rich localities.

Bill Smith
Broomfield, Colorado

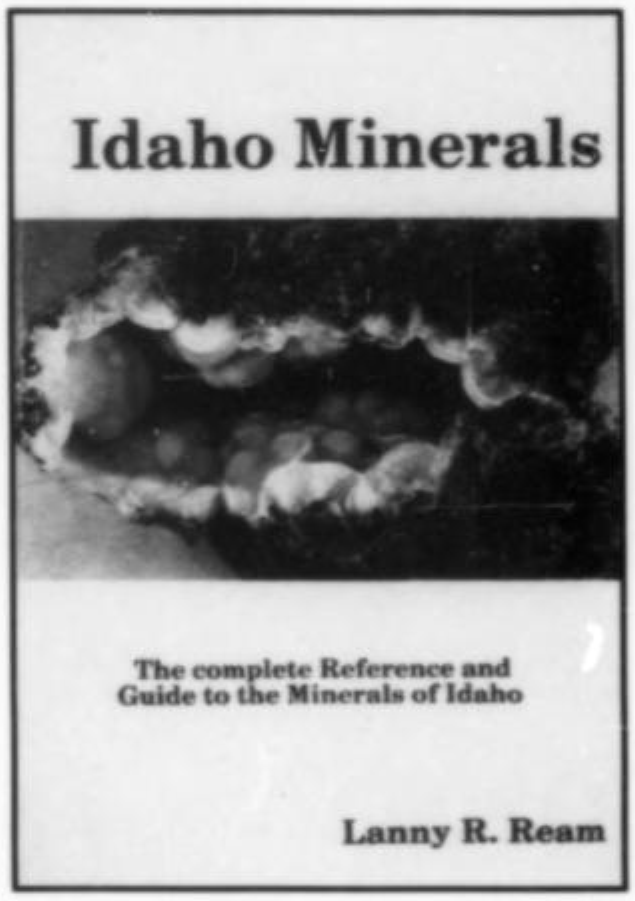
UNDERGROUND COLLECTING

I am glad you republished Steve Voynick's article on collecting in abandoned mines (vol. 20, no. 3, p. 178–180). It is the most factual, comprehensive, unemotional and best-written article on the subject I have ever read.

Art Smith
Houston, Texas

We have received requests for permission to reprint this article, but since we reprinted it ourselves we do not own the rights and cannot grant such permission. Interested parties should write to W. R. C. Shedenhelm, editor of Rock & Gem, *2660 E. Main Street, Ventura, CA 93003. Ed.*

Book Reviews

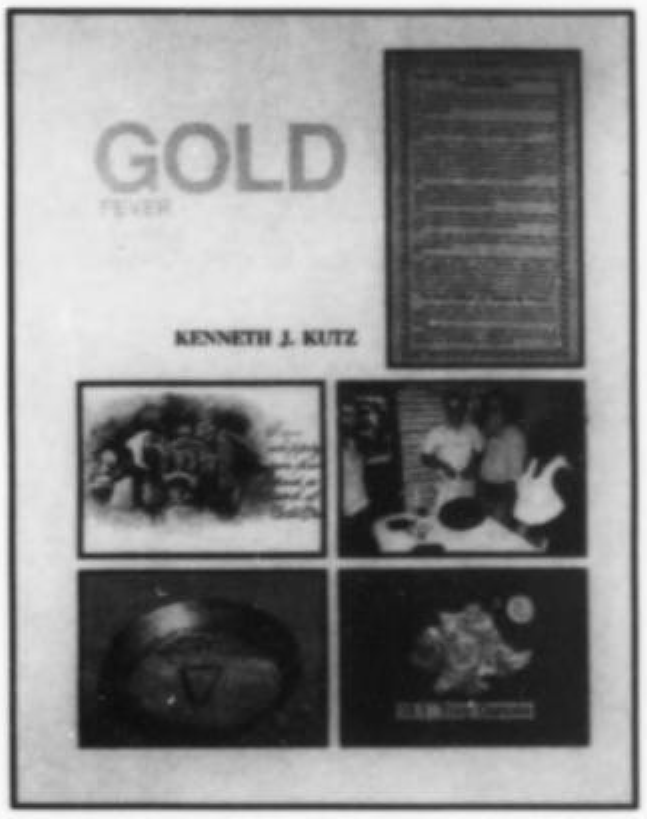


Idaho Minerals

by Lanny R. Ream. Published (1989) by L. R. Ream Publishing (P.O. Box 2043, Coeur d'Alene, Idaho 83814); 15 x 23 cm, 329 pages, hardcover ($34.95 plus $1.60 shipping) and softcover ($14.95 plus $1.25 shipping), ISBN 0-928693-02-3.

This is the first attempt to summarize the mineralogy of Idaho since Earl V. Shannon's *The Minerals of Idaho* was published in 1926, as U.S. National Museum Bulletin 131. Shannon based his work largely on the Smithsonian collection, and included mention of a great many occurrences of massive ores and very common but uncollectible species. In compiling his new book, Ream has drawn heavily on Shannon, but has excluded many of the less significant occurrences while at the same time adding many new ones that are of particular collector interest. The book contains nearly 200 black and white specimen photos and crystal drawings. A County index and a seven-page bibliography are also included. Don't throw away your copy of Shannon, if you have one; but Ream's new reference is certainly more pertinent to the modern collector, and a great deal easier to obtain.

W.E.W.



Gold Fever

by Kenneth J. Kutz. Published (1987) by Gold Fever Publishing Company (Seven Whaling Road, Darien, CT 06820). Hardcover, 22.5 x 28.5 cm, 400 pages, ISBN 0-9620411-0-6, $75 postpaid.

The author is a prominent collector of postage stamps, envelopes, letters, postcards, maps and engravings having to do with gold mining worldwide. In this beautifully produced book he gives a historical overview of gold mining, country by country and state by state, lavishly illustrated with hundreds of fascinating paper items from his vast collection. All of the memorabilia except a few sketches are pictured in full color on practically every page of the book, on high-quality coated stock (glossy paper). This is a treasure for collectors of mining ephemera, and for people interested in gold mining history. In view of the size, quality and color illustrations, the $75 price is reasonable.

W.E.W.

The Mathematical Practitioners of Hanoverian England 1714–1840

by E. G. R. Taylor. Published (1989) by The Gemmary (P.O. Box 816, Redondo Beach, CA 90277), as a facsimile reprint of the original Cambridge University Press edition of 1966. Hardcover, 14 x 22 cm, 503 pages, $67 postpaid in the U.S., $70 postpaid outside the U.S.

Despite its odd title, this book is probably the single most important reference for collectors and students of antique scientific instruments including devices of mineralogical interest. The first 106 pages review the historical background on instrument making in England from 1714 to 1840. The main portion of the book, 377 pages, gives concise biographies of 2,220 instrument makers, technicians and related instructors and scientists, including notes on the instruments they made and used.

W.E.W.

The Metalliferous Mining Region of South-West England

by H. G. Dines. Published (1988) by the British Geological Survey (ordering address: HMSO Publications Centre, P.O. Box 276, London SW8 5DT England), as a reprint, with additions of the original 1956 edition; two volumes, $30. (ISBN 0-85272-104-8)

At last Dines is available again! The two volumes of the original edition and the reprint of 1969 have been virtually unobtainable and prices asked have been very high. The price of the present reprint is not at all bad for these days and shows that the work has been subsidized. There are some additions: they have been conveniently concentrated in pages placed after the index in both volumes and have been edited by Mr. K. E. Beer. Both volumes contain maps in pockets at the back. Readers whose appetite for this book has already been whetted by the recent publication of Embrey and Symes' *Minerals of Cornwall and Devon* (1987) will want to get the new Dines as soon as possible.

Michael O'Donoghue

Quarz: Die Eigenheiten von Bergkristall, Rauchquarz, Amethyst und anderen Varietäten

["Quartz: the Peculiarities of Rock Crystal, Smoky Quartz, Amethyst and Other Varieties"] by Rudolf Rykart. Published (1989) by Ott Verlag, Thun, Switzerland, 413 pages, ISBN 3-7225-6293-7, price: DM 69.

A new book on quartz by the author of *Bergkristall* is a welcome event, especially when the many colored and black-and-white illustrations deal with European examples. Figure captions are extensive, including locality data and sizes of specimens. The book deals mainly with the crystal forms and habits taken by the varieties of quartz, and includes a thorough bibliography. The price of DM69 is amazingly reasonable.

Michael O'Donoghue

Books from Europe

by **Michael O'Donoghue**

The Gruppo Mineralogico Lombardo has long been publishing mineralogical guides to important parts of Italy. They are still in print and can be obtained from Museo Civico di Storia Naturale, Corso Venezia 55,20121 Milano, Italia.

Some but not all of the guides form part of the *Quaderni* series and I have shown this (below) where applicable. In 1968 the group published *I minerali della Valle di Fassa dove si trovano e come si presentano* (Quaderno no. 3). This deals with an area in Trentino in northern Italy where some zeolites are reported. The minerals are listed alphabetically after a section in which locations are listed with their accompanying species. Some good-quality vesuvianite and yellow andradite are found. No attempt is made by the author (Alessandro Braccio) to discuss the general geology or mineralogy of the area; the text was written in 1950.

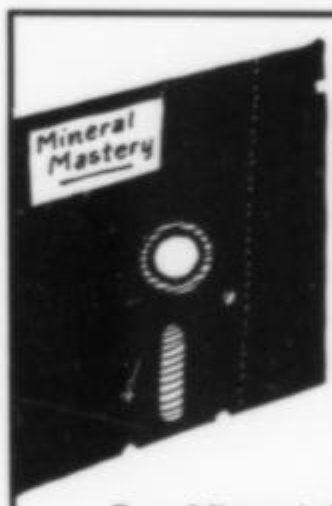
The important Ala valley (Val d'Ala) was written up by Emilio Repossi in 1919 and his report was reprinted as Quaderno no. 7 in 1970. This is a straight reproduction from the original but, as that is unlikely to be easily found (it was in the journal *Natura*), the reprint is still valuable. This is much more of a geological and mineralogical account of the area which has produced some fine green and yellow andradite crystals with some titanite, epidote and diopside.

Quaderno no. 10, published in 1973, is Roberto Torti's *La Miniera di Traversella e i suoi Minerali.* This is not a reprint but a listing of the minerals preceded by a strong section on geology and mineral occurrence. There is also a useful bibliography. Scheelite is particularly sought from this locality.

Daniele Ravagnani's *I Giacimenti Uraniferi Italiani e i Loro Minerali* was published as a separate work (not forming part of the Quaderni) in 1974. This deals with various Italian locations for uraniferous minerals and is illustrated in color. The main part of the study is a listing by area which also includes full geological and mineralogical material. Maps and plans are provided, with an alphabetical mineral index and a very extensive bibliography.

The most recent publication of the Gruppo is Giuseppe Nova's *Atlante dei Minerali di Baveno* (1987). This is a mineralogical listing, arranged alphabetically and illustrated in color, of the minerals of the Baveno area on the shore of Lake Maggiore. Drawings of crystals taken from a number of early works are included and there is a full bibliography.

I Nostri Minerali-Geologia e Mineralogia in Liguria, by Antofilli, Borgo and Palenzona, has been re-issued in two parts, the main work and a supplementary volume of 48 pages. The publisher is Sagep Editrice of Genoa, Italy. The work describes the geology and mineralogy of the north Italian province of Liguria; minerals are illustrated in color and arranged in chemical order. In the supplement a number of minerals are described and illustrated but are additional to the main work.



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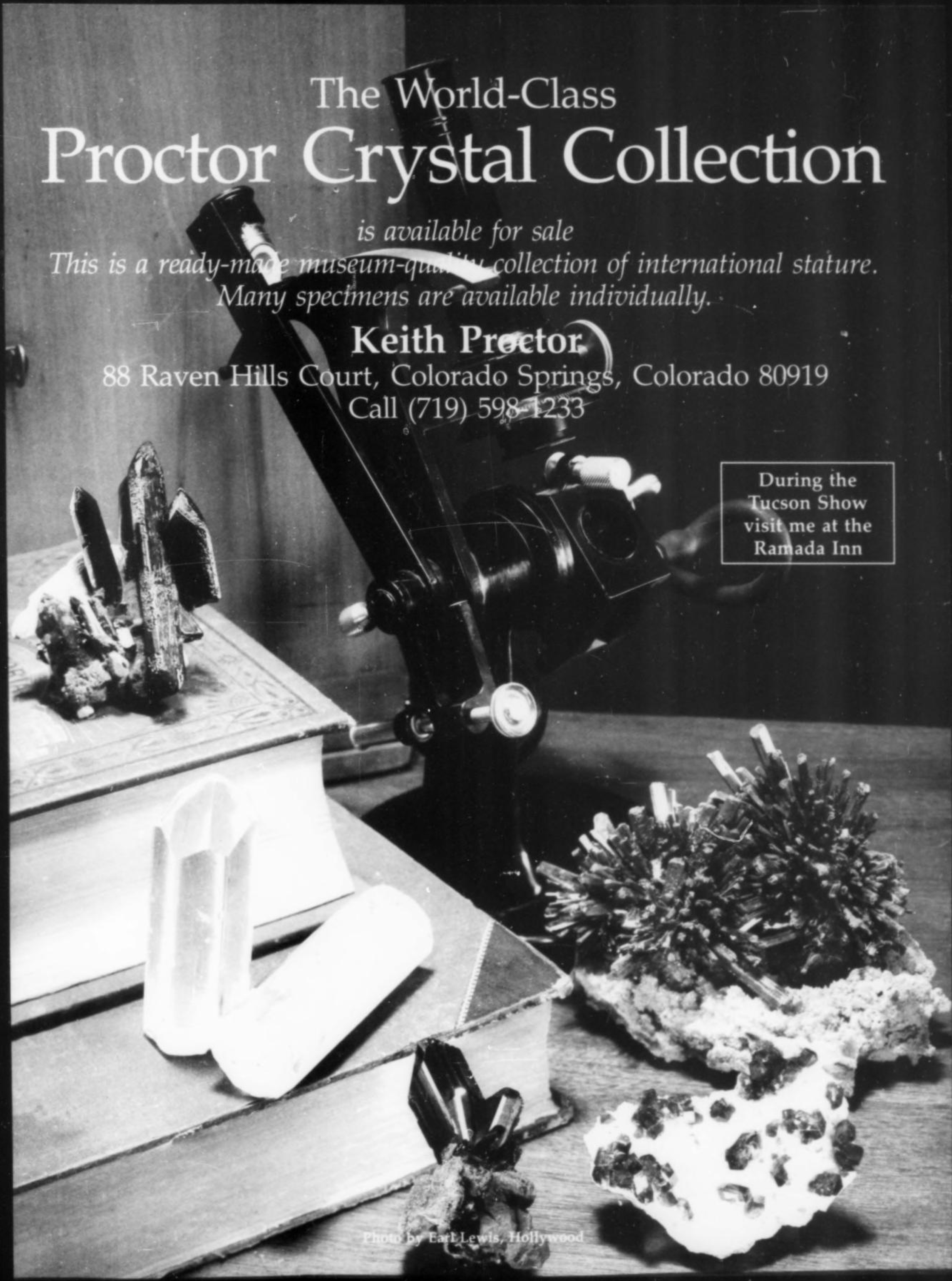
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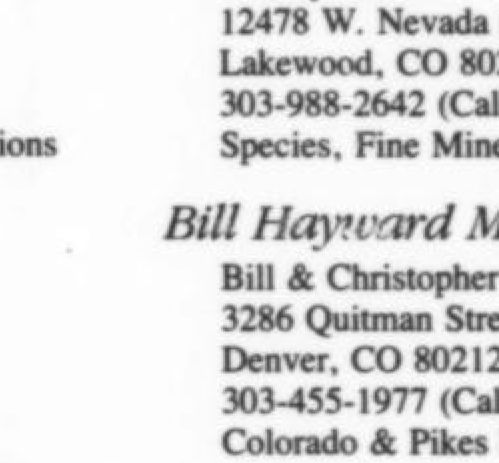

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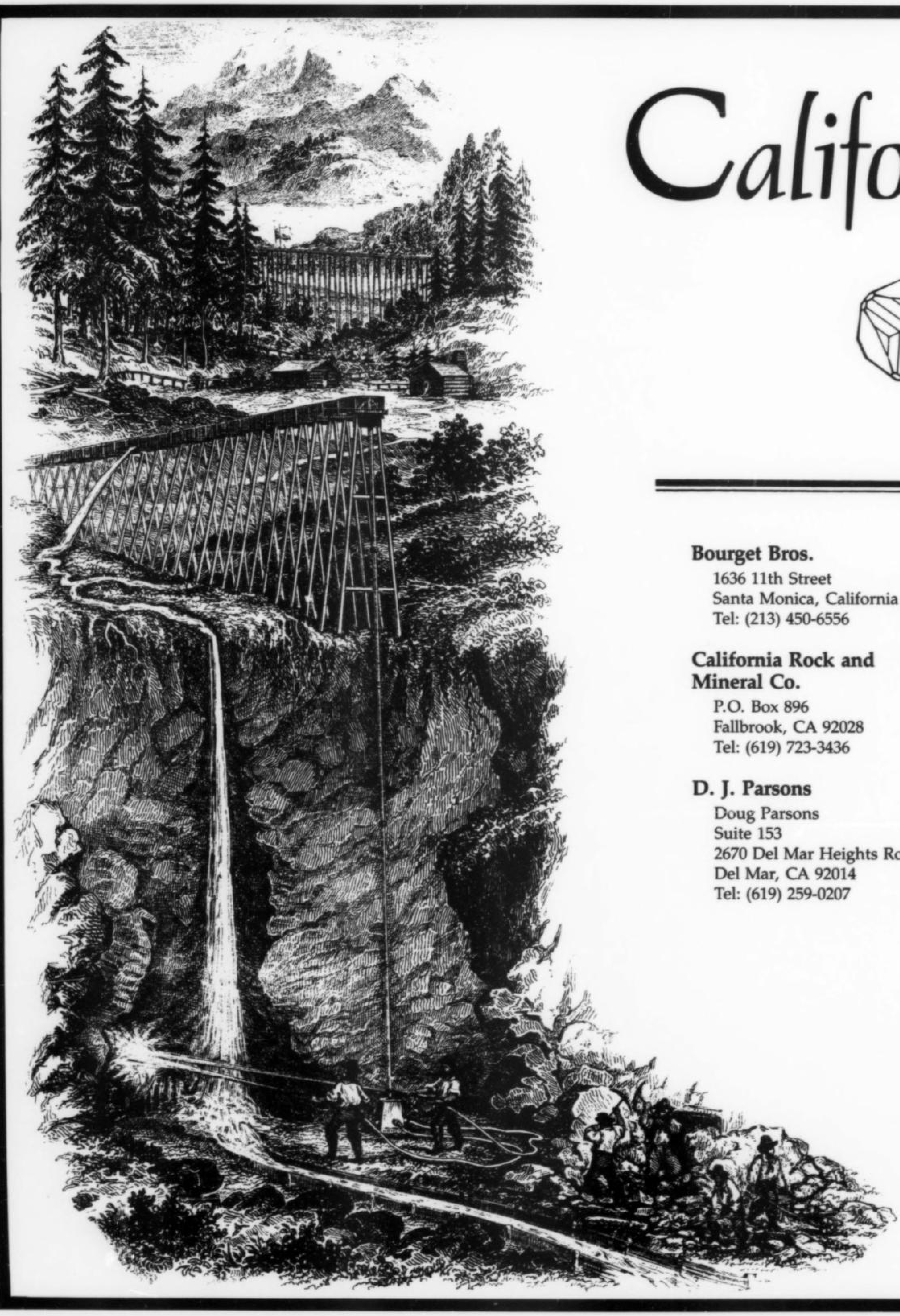

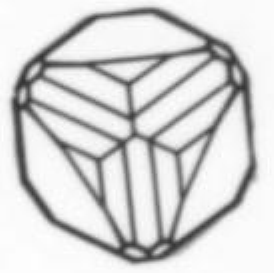

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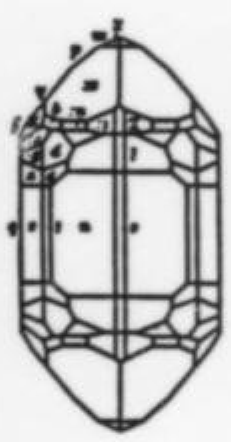

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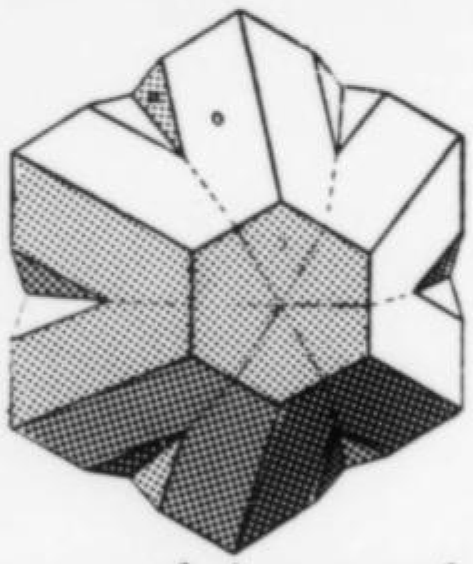

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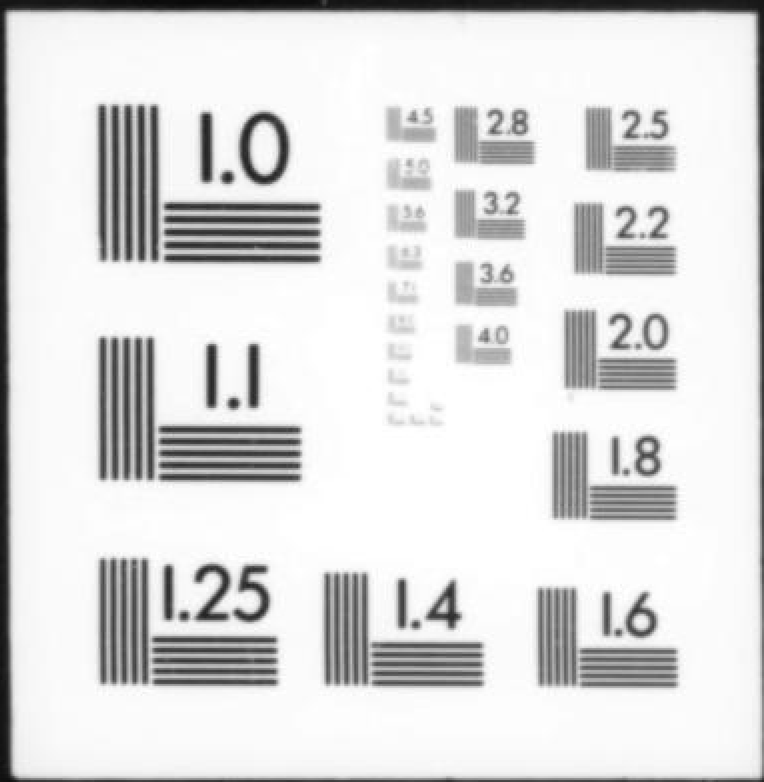
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